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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE

FOREST PRODUCTS RESEARCH BOARD

FOR THE YEAR 1934

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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE FOREST PRODUCTS RESEARCH BOARD

With the Report of the Director of Forest Products Research

FOR THE YEAR 1934

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1934

To the Lords of the Committee of the Privy Council for Scientific and Industrial Research

MAY IT PLEASE YOUR LORDSHIPS,

WE, the Forest Products Research Board, beg leave to present our Report for the year 1934.

MEETINGS

The Board met twice during the year, on 15th May at the Department of Scientific and Industrial Research, and on 26th September at the Forest Products Research Laboratory. At the meeting held in May the Board undertook a general revision of the programme of research of the Laboratory, the effect of which was to secure greater elasticity in the working of the various projects. The meeting in September provided an opportunity for members of the Board to visit the various sections of the Laboratory and to observe work in progress.

Two important questions have engaged the attention of the Board during the year. The first is the provision of means of closer contact between the work of the Forest Products Research Laboratory and timber-using industries and growers in Scotland and the North of England. The second is the development of research into problems connected with woodworking. The Board trusts that progress may be made with both these schemes as soon as financial circumstances permit.

BOX TESTING PLANT

During the year, in pursuance of earlier recommendations by the Board, a decision was reached to provide facilities for box testing in the Laboratory at Princes Risborough. These included new and special plant and a new building to hold it. It is expected that the new plant will be brought into full operation in the Spring of 1935*.

GENERAL PROGRESS

During the year satisfactory progress has been made in the research work which has been carried out under the various projects. An investigation of the effects of pruning conifer stands in the pole stage on the quality of the timber has been started and promises to yield results of considerable value to the Forestry

*The new building was opened and the plant brought into use on 10th April, 1935.

Commission and to owners of estates on which conifers have been extensively planted.

The possibility of developing a standardised test which would give a reliable assessment of the relative strengths of chairs has been explored, and a preliminary investigation, which has been a source of considerable interest to furniture manufacturers and the press, has been concluded. The results indicate that the apparatus devised for the test is likely to prove satisfactory and that the method employed, with possible slight modification, may be taken as a suitable basis for standardised test work.

Problems connected with the damage to timber by the Death Watch beetle have been brought a stage nearer solution by the conclusion of a successful attempt to breed the beetles under controlled conditions in the Laboratory. Much light has been thrown on the life-history of this pest.

Work of considerable economic importance has been in progress to determine the suitability of various home-grown timbers for use as railway sleepers, and to explore the possibility of reducing the cost of preservative treatment or alternatively of extending the useful life of sleepers in service by modifications in the methods of treatment. At the same time, impregnation tests have been carried out on home-grown poles of various coniferous species with the object of determining whether sufficient resistance to fungal decay can be ensured by antiseptic treatment to render them suitable for use as transmission poles.

Experimental work, under definitely limited conditions, has been undertaken to investigate the relative natural resistance of a number of commercial timbers to the action of fire, and to determine the relative efficacy of various fire-proofing treatments. A preliminary account of the above investigations is to be found in the report of the Director of Forest Products Research.

Work for the Empire Oversea

Full advantage has been taken of the facilities offered by the Laboratory for investigating the properties and working qualities of timbers from various oversea units of the Empire, and in the course of the year this branch of the work has attained the maximum activity consistent with our resources. Any further extension is impossible with the present laboratory accommodation. There is evidence that the relatively large increase in the consumption of Empire timbers has been due, at least in part, to the investigations which have been carried out in connection with such timbers at the Forest Products Research Laboratory. A detailed account of the work on Empire timbers is given in Appendix II.

J. C. IRVINE
Chairman

March, 1935.

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1934

1. GENERAL

Introduction

The general object of this report is to present a concise account of the work which has been in progress at the Forest Products Research Laboratory during 1934. Separate reports on the results of the various investigations are issued as they are completed; this report therefore only gives a summary of the progress which has been made in such investigations as were still proceeding at the end of the year under review.

Satisfactory progress has been made during the year in all branches of the work of the Laboratory, and appreciation of the value of the work to the timber trade and timber using professions and industries has been shown on numerous occasions in trade journals. The number of inquiries dealt with has risen from 903 in 1932 to 1,336 in 1933, and 1,739 in 1934. This increase in the amount of advisory work is a further testimony of its growing economic importance. It is interesting to note that this increase has been brought about without any increase in the expenditure of the Laboratory. To facilitate the supply of information in response to the numerous enquiries received it has been deemed advisable to re-classify all publications and records in the library of the Laboratory. The adoption of this course, and that of establishing a reliable index of vernacular and trade names of timbers has materially increased the work of the Section of Publications and Records during the year.

The desirability of making cinematograph records of certain phases of the work of the Laboratory has been considered, and work on the production of an experimental film has been undertaken, from which, when completed, it is hoped to form an estimate of the value of such records as propaganda, and to arrive at a decision with regard to future action.

In co-operation with the Building Research Station, an exhibit was staged at the Building Trades Exhibition at Olympia in September. The exhibit attracted many visitors and led to numerous requests for information and advice. Arrangements were therefore made for a similar exhibit in Bradford in January, 1935.

A policy of close co-operation with other forest products research organisations throughout the Empire has been maintained, and special tests have been undertaken on behalf of the Forest Research Institute of the Straits Settlements and Federated Malay States.

A small scale investigation of the relative resistance of various Empire timbers to the attacks of marine borers has been in progress for some time. Recently the possibility of extending the scope of the investigation has been under consideration, and it is hoped to secure the co-operation of various dock and harbour authorities and the help of various marine biological stations, in order to initiate fresh investigations on a larger and more useful scale and to relate more closely with factors influencing the life-history of the borers the problems of resistance of timbers to attack.

The number of persons of all ranks in employment at the Laboratory on 31st December, 1934, was 158. Details of the Scientific and Technical Staffs are given in Appendix 1.

Publications and Records

The increase in the work of the Laboratory since the extensions made under agreement with the Empire Marketing Board, and the subsequent work on Empire timbers, have led to a more than proportional increase in the records of the Laboratory. It was felt that on this account and in view of further possible extensive additions, the old system of classifying the records and literature was inadequate. Hence it was decided to adopt the *Classification décimale universelle*. Research work on forest products is of such recent growth, however, that even this system does not at present cover all contingencies, but the British Society for International Bibliography is co-operating with the Laboratory in an effort to remedy this defect.

With the speeding up of survey work in the forests of the timber-producing colonies, much information, not at present included in any standard works, has become available, and many new possible species for export have come to light. In some cases the correct identities of these have not yet been established, and in consequence there is no alternative to the use of native or colloquial names for them. Further, enquiries for information concerning timbers described under such names are frequently received at the Laboratory. For these reasons it has been deemed necessary to make as complete records as possible of the native names of timbers from all Empire sources. In the past, use has been made of a very incomplete index, but owing to the increased interest in Empire timbers in both home and overseas markets, the desirability of dealing with the subject more thoroughly has become apparent. The work of prepari g a new index entails a knowledge of the standard procedure adopted in connection with botanical nomenclature and will necessarily extend over a considerable period. The fact that, although only a small proportion of the work has so far been accomplished, already the number of names indexed since last June amounts to nearly 12,000 affords sufficient evidence of the magnitude of the work. Of the above, 8,000 are records of vernacular names and nearly 4,000 of botanical ones.

Requests for lectures from various organisations representing the timber-using industries and professions and from scientific institutions have now become so numerous that it has been decided to found in the Section of Publications and Records a library of lantern slides suitable for illustrating the various subjects dealt with in the lectures. The existing collection of slides is being classified and indexed, and additions will be made as occasions arise.

In order that the information obtained from the experimental work of the Laboratory may be more widely disseminated, it has been decided to issue a new series of publications to be known as " Forest Products Research Records," the first three of which are already in the press. This series will be issued at a low cost, and aims at presenting in a condensed form the results of the investigations carried out at the Laboratory, leaving the descriptions of methods used and other matters of more technical interest to be dealt with in special reports and papers presented in the scientific press. Obviously, it will be impossible to publish these Records at regular intervals, as a new issue can only be made after some investigation has been completed, but it is anticipated that there will be nine or ten numbers published in the course of the coming year.

The thanks of the Laboratory are due to the Chief Librarian, Colonial Office Library, the High Commissioners for India and certain of the Dominions, the colonial forest services, as well as many private individuals, for numerous valuable gifts to the Library during the past year.

Collection of Wood Specimens

The supply of authentic timber specimens, collected with due regard to the need for botanical accuracy, is essential to the efficient working of the Laboratory. Grateful acknowledgements must be made for valuable additions to the collection from the Imperial Forestry Institute, the New York State College of Forestry, the Imperial University, Tokyo, the Laboratorio de Ensaio de Materiaes, San Paulo, Brazil, the Scientific Research Institute for Aircraft Materials, U.S.S.R., Messrs. Fraser Brace, Ltd., Montreal, and from forest departments in the dominions and colonies. The total acquisitions for the year amount to 1,395, including nearly 500 named species not previously represented in the collection. At the end of the year the total number of catalogued specimens amounted to 7,929, representing 2,849 separate species.

Mention should also be made of co-operation between the Laboratory and the Imperial Forestry Institute in wood structure research, which continues to be of mutual benefit.

II. THE PROGRAMME OF RESEARCH

Variation in the Structure of Wood

With a view to elucidating the principles which govern variation in the structure of wood, statistical methods of analysis have been applied to large numbers of anatomical measurements which have been accumulated over a period of years in the course of investigations on timbers from temperate and tropical regions. During the year some results of these investigations have been published[1]. In the first of the two papers cited, the selection of samples for microscopic examination and the number of observations necessary to achieve a definite degree of accuracy are considered. The second paper discusses the significance of anatomical measurements in the identification of timbers and includes a tentative scheme for standardising technical descriptions. The diversity of methods employed by different investigators has undoubtedly hindered progress in this subject. A movement towards standardisation is being made by the International Association of Wood Anatomists, and it has been possible to put forward constructive suggestions to the Committee appointed to make recommendations on this matter.

[1] Rendle, B. J., and Clarke, S. H. The Problem of Variation in the Structure of Wood. *Trop. Woods*, 1934, **38**, 1–8. Ibid. The Diagnostic Value of Measurements in Wood Anatomy. *Trop. Woods*, 1934, **40**, 27–37.

The Relation between the Structure and the Technical Properties of Wood

The study of the structure of wood in relation to its technical properties is a project which involves co-operation between the various sections of the Laboratory. Advances have been made by examining the structure of specimens which have been tested under standard conditions and found to be abnormal in some respect. In connection with wood-working tests, an abnormally fibrous surface resulting from a machine-planing test has been traced to the relative distribution of the hard and soft tissues in the species concerned, and in this case the nature of the peculiarity indicated the means of overcoming the defect. It has also been found that in certain timbers an abnormal condition of the fibre walls affects their machining properties, as well as their reactions to seasoning processes, and this is being investigated further.

Before the influence of abnormal structural features can be properly understood, a sound knowledge of the behaviour of normal wood is of course essential, and this is being gradually built up from the structural examination of timbers investigated in the Laboratory. Chemical analysis of matched samples has also been carried out in certain instances, in order to determine whether any direct relation exists between variations in the chemical composition of the wood and the technical properties of the timber. With regard to the

structure of wood in general, it has not been overlooked that the ultra-microscopic structure of cell walls may have to be taken into account, but so far practical work under this head has not been attempted.

The study of wood structure as it affects the mechanical strength of wood is the subject of a special investigation, which is referred to elsewhere in this report.

The Structure and Properties of Commercial Timbers

Satisfactory progress has been made in the systematic botanical study of timbers, with special reference to species of economic importance in the United Kingdom. Particular attention has been given to the Coniferæ, the Myrtaceæ and the mahoganies and allied timbers. Much of the work of previous investigators has been done on inadequate material or has been limited to the timbers of one country. A survey of a large natural or commercial group of timbers therefore involves a critical study of past work combined with the investigation of specimens in the Laboratory collection. This work occupies an important place in the research programme of the Wood Structure Section, as it forms the basis of investigations on the structure and properties of timbers and is also the means of building up knowledge essential to the identification of timbers and general advisory work.

Moisture Relations of Wood

Progress has been made in the study of the moisture relations of wood in the neighbourhood of the fibre saturation point. During the year more refined experiments on the amount of water adsorbed by the wood, as measured by the change of concentration of a sugar solution with which the dried wood is mixed, have shown that, as the concentration of the solution used was increased, the amount of water which was abstracted from the solution by the wood decreased. By thermodynamic reasoning it is possible to calculate the relations between these two variables from a knowledge of the vapour pressures of the wood at different moisture contents and of the solutions at different concentrations. Such calculations have shown that the observed effect cannot be quantitatively explained unless a certain adsorption of sugar is also postulated. The amount of sugar adsorbed appears to be roughly proportional to the solution concentration and is quite small (for a 5 per cent. concentration of sugar, the adsorption amounts to less than 1 per cent. of the dry weight of the wood, the water adsorption being about 30 per cent.).

With a view to making these measurements to a greater degree of accuracy, apparatus has been constructed for measuring the change in moisture content with relative humidity of Sitka spruce wood flour and is working satisfactorily. Particularly interesting

results have already been obtained with this apparatus in the neighbourhood of the saturated vapour-pressure (100 per cent. relative humidity), which throw doubt on the generally accepted values of the so-called fibre saturation point of wood. The fibre saturation point is the minimum moisture content of the wood which is in equilibrium with a saturated atmosphere of water vapour, and for Sitka spruce it is usually taken as about 25 per cent. moisture content. When, however, the vapour pressure was measured, as in these experiments, to a greater degree of accuracy than hitherto, it was found that at this moisture content the vapour pressure is not in fact saturated and that the moisture content rises very rapidly as the last 0.5 per cent. relative humidity is established. The actual end point is indeterminate but must lie at least at 40 per cent. and possibly over 80 per cent. moisture content. Furthermore, on drying the wood from high moisture contents, the vapour pressure drops to 99.5 per cent. relative humidity at a moisture content of over 70 per cent. The well-known hysteresis between the wetting and drying curves, therefore, extends to moisture contents very much above the previously assumed fibre saturation point where it was supposed to have disappeared.

These observations are at present in their early stages but are to be followed up during the coming year. Since the fibre saturation point appears to be so much higher than was previously assumed, it has been necessary to enquire into the causes of the discrepancy, and it has been found that in the determination of the fibre saturation point by the standard method of shrinkage measurements, there is, in fact, evidence of shrinkage commencing at these high moisture contents, but this has hitherto been put down to possible effects of unequal drying. More refined shrinkage measurements are now being undertaken to test this point. The other standard determination of fibre saturation point is by measuring the maximum crushing strength of small samples at all moisture contents from green to dry, when a sharp break in the strength-moisture content curve occurs at what is taken to be the fibre saturation point. This method, however, neglects the effect of external pressure on the wood which is to raise the vapour pressure of the material. Hence specimens originally below the true fibre saturation point may, as a result of pressure, be raised to the fibre saturation point before failure occurs. Theoretical investigation shows that there is quite good evidence that this is indeed the case, and that for Sitka spruce the break in the curve at 25 per cent. moisture content occurs for samples previously in equilibrium with about 95 per cent. relative humidity.

Statistical Methods

During this year more attention has been turned to the use of statistical methods in the planning of Laboratory experiments as distinct from their use in the analysis of results. In the case of a

fire-resistance test, it was possible from preliminary experiments to fix a fairly low number of replicate test pieces and yet know that the smallest difference it was desired to detect would be shown with considerable certainty. In another experiment, on the fumigation of timber against beetle attack, larvæ of wood-destroying insects were to be exposed to various concentrations of hydrogen cyanide gas. By ensuring a certain minimum representation of age groups in each group of insects, it was possible to increase the efficiency of the experiment and thus obtain more, and more certain, information from a given amount of material. A similar plan was drawn up for an air-seasoning experiment in which several features of the influence of piling on the drying rate were to be investigated in the same experiment.

The statistical method of dealing with data has also revealed an important problem, the existence of which could not otherwise be established, namely, that a difference in strength exists in timber from trees of the same species. More variation in strength is found from tree to tree than might be expected from its variation within any one tree. These differences between trees can, of course, be ascribed to difference of sites and environments during growth, but though these assumptions are probably correct it is still true that there should be some more direct indication of this influence of environment than a variation in strength. This indication, perhaps structural, perhaps chemical or physical, has still to be sought, and, until it is found, predictions of strength or the reasons for failure under stress will be subject to the present uncertainty. Where material is limited there is a natural tendency to take as many test pieces as possible from each tree, but this gives undue weight to those trees which yield large numbers of test pieces. The analysis is thus complicated without increasing the reliability of the deductions, so that the practice, for many purposes at least, is unduly costly.

Thermal Diffusivity

Measurements have been made, by the method an account of which has been published[1], of the thermal diffusivity of several common woods in the three directions relative to the grain. These woods have been selected to show extremes of certain structural features which might be expected to influence the diffusivity. A start has been made on the measurement of the diffusivity of green wood.

[1] Van Rest, E. D. A Method for the Measurement of the Thermal Diffusivity of Poor Conductors. *Proc. phys. Soc.*, 1934, **46**, 537–544.

Cell Space Ratio

An account of the photo-electric measurement of the cell space ratio of woods, which was described in the annual report for 1933[1], was read before the Physical Society in May and was subsequently published[2].

Since this account was prepared further work has been commenced with a view to simplifying the technique by using a Westinghouse green-sensitive photocell instead of the vacuum cell previously employed. This should result in a considerable simplification, since these photocells give sufficiently large electric currents to render valve amplification unnecessary.

The apparatus is now housed permanently in the new dark laboratory which the Physics Section has acquired during the past year.

(1) *Report of the Forest Products Research Board for the Year* 1933. H.M. Stationery Office, 1934.

(2) Barkas, W. W. Measurement of the Cell Space Ratio in Wood by a Photoelectric Method. *Proc. phys. Soc.*, 1934, **46**, 545–558.

The Shrinkage of Wood

It has been observed that the amount of shrinkage of timber from the green to the dry condition is not necessarily a criterion of the " working " or " movement," *i.e.*, the expansion, contraction or distortion of the dry timber when subjected to changing atmospheric conditions.

With the object of studying the relations between the shrinkage during drying and the subsequent " working " of wood, a series of experiments has been put in hand, in which small samples of the commoner species are first slowly dried from the green and then slowly re-wetted and re-dried over a moisture content range of from 8 to 20 per cent. The relations between the total shrinkage and the " movement " per unit change in moisture content can thus be established.

Routine measurements of shrinkage are being continued, and the study of the influence of the method of drying upon shrinkage is receiving further attention.

The Relations between the Moisture Content of Wood and the Surrounding Hygrometric Conditions

The relations between the moisture content of wood and the surrounding hygrometric conditions have again received increasing attention, as the subject is clearly one of great importance, both from the point of view of selecting a particular timber for a specific purpose and from that of assessing the degree of seasoning desirable for different requirements.

Fig. 1 shows a chart which has been prepared to serve as a general indication of the moisture contents to which timber should be seasoned to suit various environments.

The " working" (*i.e.*, the shrinkage and expansion) of further species when submitted to normal seasonal changes of atmospheric temperature and humidity has been examined over a moisture content range covering the extreme conditions likely to occur in ordinary use in this country. Full observations have been made

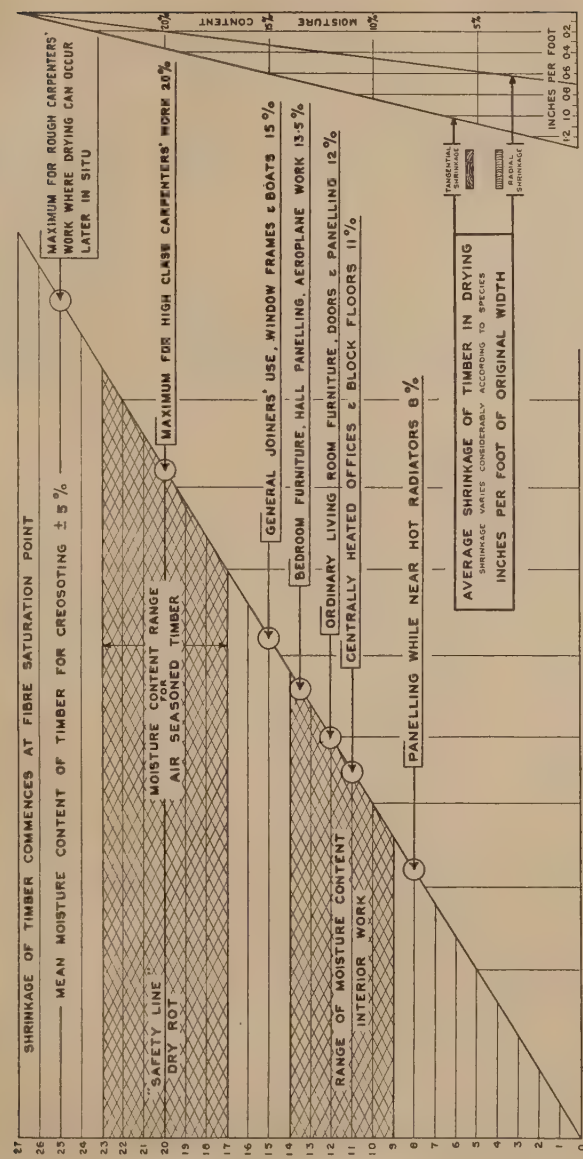
THE FIGURES FOR DIFFERENT SPECIES VARY, AND THE CHART SHOWS ONLY AVERAGE VALUES
SHRINKAGE OF TIMBER COMMENCES AT FIBRE SATURATION POINT
MEAN MOISTURE CONTENT OF TIMBER FOR CREOSOTING ± 5 %
MAXIMUM FOR ROUGH CARPENTERS' WORK WHERE DRYING CAN OCCUR LATER IN SITU
MAXIMUM FOR HIGH CLASS CARPENTERS' WORK 20%
MOISTURE CONTENT RANGE FOR AIR SEASONED TIMBER
SAFETY LINE
DRY ROT
GENERAL JOINERS' USE, WINDOW FRAMES & BOATS 15 %
BEDROOM FURNITURE, HALL PANELLING, AEROPLANE WORK 13·5 %
ORDINARY LIVING ROOM FURNITURE, DOORS & PANELLING 12 %
CENTRALLY HEATED OFFICES & BLOCK FLOORS 11%
PANELLING WHILE NEAR HOT RADIATORS 8 %
RANGE OF MOISTURE CONTENT
INTERIOR WORK
AVERAGE SHRINKAGE OF TIMBER IN DRYING
SHRINKAGE VARIES CONSIDERABLY ACCORDING TO SPECIES
INCHES PER FOOT OF ORIGINAL WIDTH
TANGENTIAL SHRINKAGE
RADIAL SHRINKAGE
MOISTURE CONTENT
INCHES PER FOOT
MOISTURE CONTENT %
APPROXIMATE AIR HUMIDITIES CORRESPONDING WITH MOISTURE CONTENTS OF TIMBER
20% 35% 50% 60% 70% 77·5% 85% 90%

FIG. 1.—*Chart of Moisture Contents of Timber for Various Purposes*

The figures for different species vary, and the chart shows only average values.

on solid panels of oak, mahogany, red deal and teak, and on plywood or built up panels ranging in thickness from $\frac{1}{8}$in. to $1\frac{1}{4}$ ins. In addition, the " working " of twenty-four different species when kept in an ordinary office has been observed.

The moisture content changes occurring throughout the year are being observed for an increasing number of species which are kept under various conditions (*e.g.*, in an office, a bedroom, etc.), and in all, over 50 species have now been studied over a period of one year. Fourteen further species were studied during the year under review.

The work of studying the behaviour of wood samples placed in new buildings has been continued. In last year's report reference was made to a building in which the rooms were ventilated by artificially conditioned air (Fig. 2). As the temperature and humidity conditions are ostensibly maintained constant throughout the year, it would be expected that once the building had dried out the

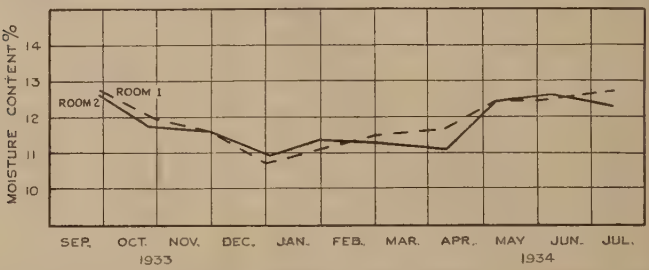

FIG. 2.—*Moisture Content of Joinery in Two Rooms of a Building Heated and Ventilated by Conditioned Air*

moisture content of the timber work would remain constant. This was not found to be the case, however, although the range of variation observed in the moisture content was only about plus or minus one per cent., or about half the change which takes place in an ordinary centrally heated building.

In previous reports, references were made to a process known as re-conditioning, whereby much of the distortion and collapse which had occurred in seasoning could be removed. It has been thought by some that this process gave subsequent stability to timber in use, and in order to observe how the " working " of re-conditioned timber compared with that of timber not so treated, matched re-conditioned and untreated boards were studied when exposed to wet and dry environments. Air-seasoned and kiln-seasoned boards of oak, elm, and ash, re-conditioned and untreated, were measured for " working," and it was found that there was no significant difference. Similar tests on East African pencil cedar (*Juniperus procera*) indicated that the re-conditioned material shrank and expanded more than the untreated, and this was accounted for by the wood having become more hygroscopic as

a result of the steaming treatment. The peculiar behaviour of this timber appears to be an exception and is probably due to the presence of natural oils, some of which may have been removed or modified in the re-conditioning process.

In collaboration with the Division of Forest Products of the Council for Scientific and Industrial Research of the Australian Commonwealth, the study of the moisture changes of seasoned timber during sea-transit to this country from Australian ports, as indicated by the moisture contents of the timber at the beginning and end of the voyage, has been undertaken. Two consignments of Tasmanian oak flooring (*Eucalyptus obliqua* l'Herit.), kiln-dried to approximately 13 per cent., have been observed, and it has been found that the change in moisture content is so small as to be negligible for all practical purposes. The stowage conditions in each case were extremely good, but the experiments serve to show at least what can be expected under favourable conditions.

The Measurement of the Moisture Content of Wood

In recent years a number of instruments have been developed for the rapid determination of the moisture content of wood. These instruments are electrically operated and measure the electrical resistance or capacity of the wood, such measurements being calibrated in terms of moisture content. With the object of investigating the capabilities of one of these instruments, a " Blinker " Moisture Meter, based on a design originally developed at the Forest Products Laboratory, Madison, Wisconsin, U.S.A., has been constructed. The meter has a moisture content range of from 8 to 24 per cent., and has been calibrated to give direct readings of the moisture content of Douglas fir. Corrections will have to be applied for other species, and these corrections are being determined.

In some cases it is not practicable to apply the usual method of cutting a section in order to determine the moisture content by the ordinary method of oven-drying. Even if a moisture meter is available, the results may be unreliable as the latter method explores only the surface layers of the timber. In such cases, the method of making borings and determining the moisture content by oven-drying the chips obtained from the borings may be employed. In order to check the accuracy of the boring method, comparisons were made with the standard method of oven-drying and it was found that, provided there was no loss of time in weighing the borings, there was no appreciable difference in the accuracy of the two methods. A satisfactory alternative to immediate weighing was also found in immediately placing the borings in a bottle for subsequent weighing. The manner in which the moisture is distributed can be gauged to some extent by regulating the depth of the bore-hole, or discarding the chips removed first.

Kiln-Seasoning Experiments

The experimental kilns at the Laboratory have been in constant use, and much additional information on the kiln-seasoning characteristics of timbers, and the design and operation of kilns, has been collected. Kiln experiments on a large scale have been made on beech (*Fagus sylvatica* L.), Dutch elm (*Ulmus hollandica* Mill.), Norway spruce (*Picea Abies* Karst), common elm (*Ulmus procera* Salisb.), oak (*Quercus Robur* L.), sweet chestnut (*Castanea sativa* Mill.), sycamore (*Acer Pseudoplatanus* L.), Sitka spruce (*Picea sitchensis* Carr.), walnut (*Juglans nigra* L. and *Juglans regia* L.), opepe (*Sarcocephalus Diderrichii* De Wild.), East African olive (*Olea Hochstetteri* Baker), and slash pine (*Pinus caribæa* Morelet).

Many of these experiments have been carried out on dimension stock (*e.g.*, furniture squares, rifle blanks, flooring, etc.). Kiln-seasoning from the green, as applied to small sizes such as furniture squares, appears to offer promising economic possibilities, even where kiln-seasoning from the green in plank form could not be recommended except in special cases. Further information has been collected on the kiln-drying of partly air-seasoned timber, and in this connection a new departure has been made. A consignment of Carpathian beech, in the sizes and grades largely used in this country, has been purchased in the " shipping dry " condition and kiln-seasoned at the Laboratory. A similar experiment on American oak is planned for 1935.

Whereas 2-in. beech squares can be successfully kiln-dried from the green in under three weeks, and 2-in. Dutch elm squares in a fortnight, oak and sweet chestnut squares of the same size require 7 and 5 weeks respectively, which would appear to indicate that some preliminary air-seasoning is advisable.

Heat Losses in Kilns

Measurements of the steam consumption in kilns and investigations into the manner in which the heat is dissipated have shown that a very considerable heat loss may be due to air and vapour leakages in the vicinity of doors, drains, etc., especially in forced draught kilns. It was found also that a very considerable saving of steam could be effected by a careful regulation of the air interchange through suitably designed inlet and exhaust air ducts. The very large proportion of heat lost through the walls of a kiln by conduction and radiation will, of course, depend mainly upon the insulation qualities of the structure as a whole. Tests have shown that such losses may greatly be augmented by increase in the humidity of the air within the kiln. This increase is usually due to the fact that the temperature of the inside surface of the wall is frequently lower than the dew point, and hence considerable condensation may occur. As a result of such condensation the heat

transmission between the air and the wall is increased, and in addition the material of which the wall is made usually absorbs a considerable quantity of moisture, and thus conducts the heat more readily.

The Effect of Varying Air Speeds on Drying Rates

Preliminary tests to determine the effect of air speed through the timber pile on the drying rate have been carried out on small loads of beech. Tests were made in a small kiln on a pile width of 3ft. 6ins., and varying air speeds were obtained by a suitable arrangement of baffles and control of the speed of the fan. The results obtained showed that the average drying rate of the pile as a whole increased rapidly as the air speed between the layers was increased until an average speed of one foot per second had been reached. Further increases in the air speed resulted in comparatively small increases in the drying rates. These preliminary tests were carried out under conditions such that the timber dried fairly rapidly, and further tests have been planned to determine the optimum air speeds for various drying conditions and piling methods.

Variation in Drying Rates in Different Types of Kilns

Comparative tests have been carried out on two moderately refractory timbers, previously air-dried, to determine the relative drying rates occurring in typical forced- and natural-draught kilns. Using identical drying schedules, the tests indicated that the drying time in a natural-draught type of kiln is approximately 50 per cent. longer than the time taken in a fan type of kiln.

Alterations and Extensions to Kiln Plant

The conversion of the water-spray kiln to the internal-fan cross-circulation type of kiln, referred to in last year's Report, was completed early in the year, and several loads of timber have been dried successfully. The kiln functions in a reasonably satisfactory manner, but so far it has not been found possible to obtain such uniform conditions of temperature and humidity as in the overhead internal fan kiln.

It is common commercial practice to load timber for kiln-drying on cars or trolleys in such a way that the load can be run into the kiln without delay. The kiln can then be in almost continuous use and in addition, the labour of piling is reduced, since piling timber in the comparatively cramped space of a kiln is relatively awkward. In order to obtain first-hand data on the advantages and possible disadvantages of trolley loading, the basement internal-fan kiln is being equipped with rails and trolley.

For some time the need has been felt for a kiln that would provide drying data comparable to that of a full-scale kiln, and at the same time require very much less timber to fill the chamber. This need

has now been met by the construction of a kiln having approximately the same cross-sectional dimensions as a full-scale commercial kiln, but of about one-third the length. The pile width, which, other things being equal, is the most important factor in influencing drying time, is thus the same for the new kiln as for most existing commercial kilns. The kiln (Fig. 3) is of the overhead internal fan type but has the fan-shaft mounted in a direction at right angles to that in the usual type. The kiln was completed in the summer and has proved entirely satisfactory.

As mentioned earlier in this report it has been found that leakage round the kiln doors is responsible for a big increase in steam consumption, and consequently attention has been devoted to devising and constructing better-fitting doors. Two doors of the comparatively flexible type, in which the door is pivoted centrally and is pulled into place on all edges by means of latches working in wedge-shaped slots, have been constructed and have proved greatly superior to the ordinary side-hung doors. In addition a door of the drop-in type is being fitted to one of the kilns. In this case the door is carried into position by an overhead carrier and is then dropped into slots so arranged that the door is forced against the frame by its own weight.

An old pump pit, used in connection with the obsolete water spray kiln, has been converted to a special kiln-paint testing chamber. This is intended for testing the various paints used or suggested for protecting kiln walls, pipes and gear, and end-coating paints for timber. The test pit is equipped with sections of steam piping, walls, etc., which can be treated with different paints, and is provided with steam heating and humidification so as to reproduce the conditions inside a kiln. A small chamber is provided with forced circulation for testing the efficacy of paints designed to protect the ends of timber from splitting owing to their drying too quickly relative to the timber as a whole.

A portion of an existing motor and fan pit has been converted into a warm chamber for drying and setting timber that has been bent on the steam bending machines.

Air-Seasoning

Earlier investigations proved that green softwoods in boards 2 ins. thick, if piled for air seasoning in the spring, would dry to moisture contents of 25 per cent. and 20 per cent. after 2 and 3 months respectively. In order to ascertain the influence of piling in the autumn, an air-seasoning pile of $2\frac{1}{2}$-in. softwood was erected in the autumn of 1933. It was found that in four months the moisture content fell to 30 per cent., in five months to 25 per cent., and in six and a half months to 20 per cent. The conclusion is, therefore, that nothing is gained by piling softwoods that would normally dry in a few months, before the early spring. Where the drying period is of the order of one year, however, autumn piling is

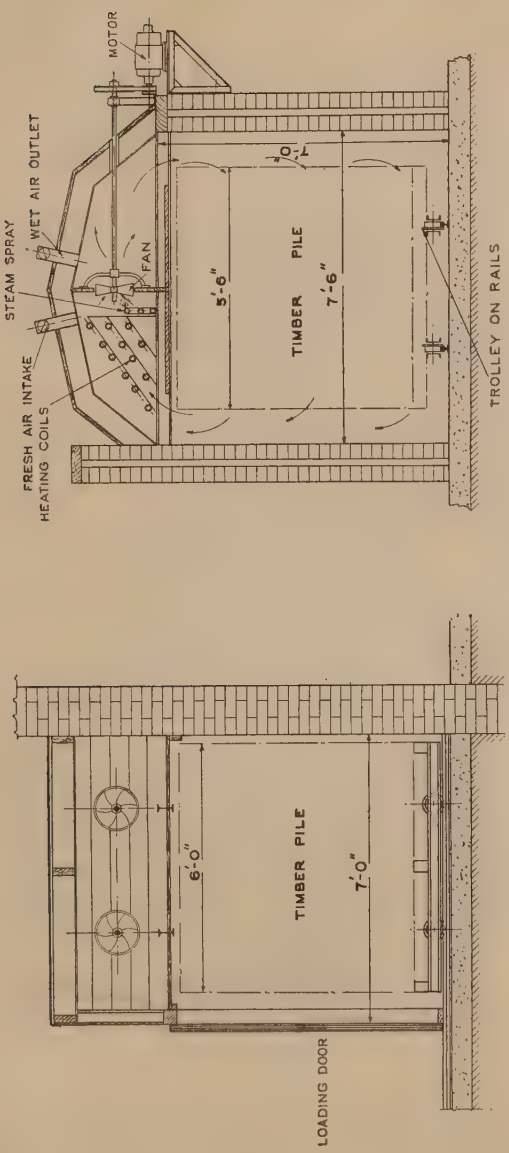

FIG. 3.—*New Kiln of Bulkhead Type*

advantageous, as the timber may be used in the following autumn, but if piled in spring it would not be sufficiently dry in the autumn, and no further drying would take place until the following spring, and thus 3–4 months would be wasted. In the case of refractory timbers, an initial winter exposure is valuable, as the drying conditions are mild, so that the seasoning degrade is reduced to a minimum. With the advent of dry weather the timber is then partly seasoned and has, therefore, a greater resistance and less tendency to check and split.

Previous experiments on oak and elm have demonstrated that practically no drying takes place while the timber is left in the log. An opportunity occurred of testing the distribution of the moisture in logs of oak and elm that had been exposed in the open for more than ten years. Fig. 4 shows in diagrammatic form the manner in which the moisture was distributed. It is clear that practically no drying has taken place.

In the drying of large furniture squares, such as those used for table legs, it is sometimes customary to bore a hole down the centre of the square to accelerate the drying. In order to investigate the influence of this practice on the drying rate, a series of experiments has been put in hand dealing with oak, elm and chestnut in the form of 5-inch squares. Fig. 5 shows the drying curves for the elm squares up to November, 1934, and incidentally illustrates the

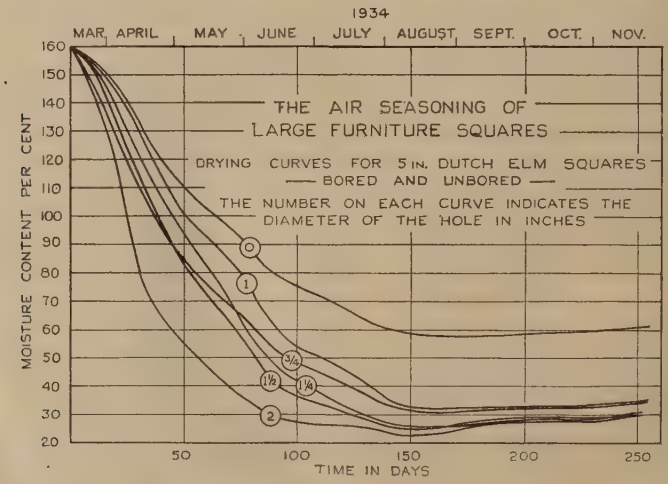

FIG. 5.

point mentioned just above—that little or no drying takes place in the winter if the timber is already fairly dry in the autumn. It will be observed that whereas there is a very marked difference in

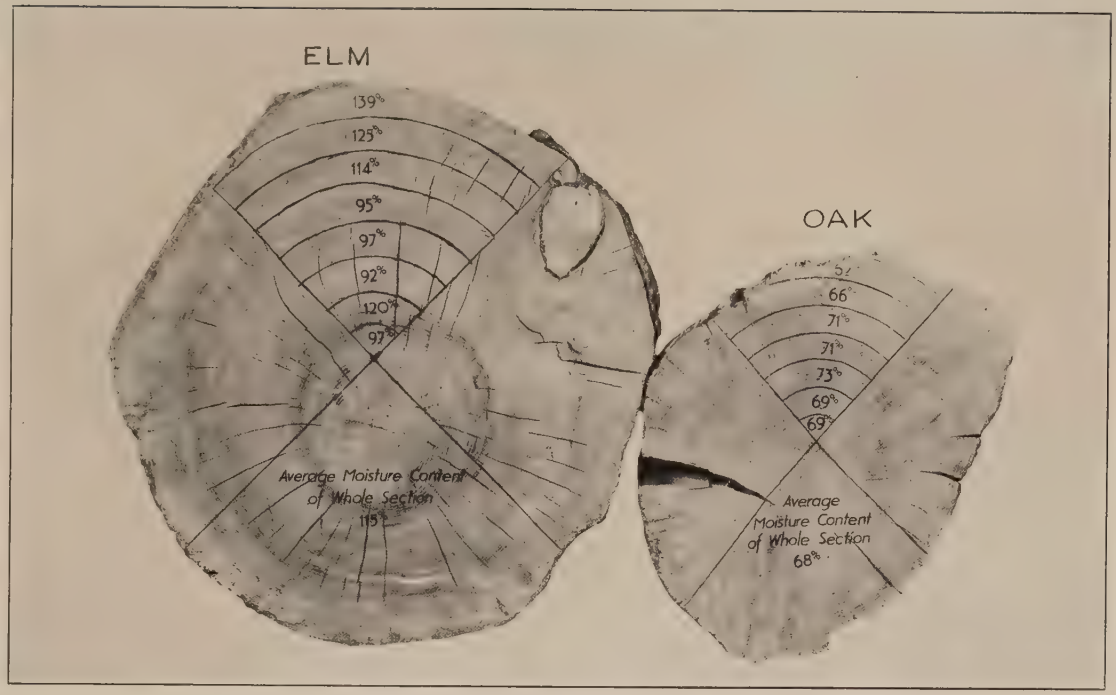

FIG. 4.—*Distribution of Moisture in Round Timber*

The sections of elm and oak were cut from logs stored in the open for over ten years after felling.

The high moisture content of the whole and particularly of the outer portions show the drying to be practically negligible in this period.

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the drying rate between the unbored and bored squares in the initial stages, the size of the bore-hole does not affect the drying rate to any great extent once the timber begins to get fairly dry.

Steam Bending

Investigations into the bending qualities of beech and wych elm have been completed during the year, and an investigation into the bending qualities of Dutch elm is now in progress.

Tests have shown that the effect of using a pressure much above 10 lb. per sq. inch in the preliminary steaming process is detrimental to the wood, in that discoloration often results, and the material tends to become so soft that crumpling and creasing occur as soon as the necessary bending pressures are exerted. The optimum moisture content for all the woods so far tested appears to be about 20 per cent. Green wych elm is extremely prone to failure in compression, and there is reason to believe that this failure is due to the hydraulic pressures set up by the water in the cells of the compressed face. This trouble is not experienced with the dried material, and in this state it proves to be an extremely good bending wood.

Small scale investigations have been carried out on the bending qualities of the following Empire timbers: okan (*Cylicodiscus gabunensis* Harms.), mninga (*Pterocarpus angolensis* DC.), coachwood (*Syncarpia laurifolia* Tenore), Nigerian celtis (*Celtis?Soyauxii* Engl.), yemeri (*Vochysia hondurensis* Sprague), opepe (*Sarcocephalus Diderrichii* De Wild.), odoko (*Scottellia coriacea* A. Chev.), blackwood (*Acacia melanoxylon* R. Br.), blackbean (*Castanospermum australe* A. Cunn.), and uhu (*Diospyros insculpta* Hutch. et Dalz.). Of these, the only species at all suitable for bending was uhu (*Diospyros insculpta*), which was found to be comparable with beech, except that rather higher pressures were required.

Several enquiries have been made as to the possibilities of adapting the existing bending machine at the Laboratory for commercial purposes, and this problem is at present receiving attention, as only slight modification would seem to be necessary to produce an effective apparatus.

Tests to determine the stress-strain relations of steamed timbers both in tension and compression have been made by the Section of Timber Mechanics, and these have proved of considerable value for making rapid estimations of the bending qualities of any species. From these data an approximate estimate can be made of the minimum radius around which a specimen of unit thickness may be bent without failure occurring. This figure is of considerable value in assessing the bending qualities of a new species, and the method has the advantage that a very small volume of timber is required for such tests.

The Relation between the Structure of Wood and its Mechanical Strength

During the year under review, in continuation of the study of the relations between structure and strength, two further consignments of ash have been tested. The results of these tests showed reasonable agreement with those obtained from the first two consignments previously tested, though not the third, the high strength of which, relative to its specific gravity, cannot be related to the structural features investigated and has not yet been satisfactorily explained. Standard methods of chemical analysis have so far failed to reveal differences which might account for it. It is possible that special analytical methods may reveal chemical differences which, though small in themselves, exert disproportionate effects on the properties of the timber.

It is reasonable to assume that conditions of growth may influence the properties of the wood through some characteristic of its structural or chemical composition which has not yet been adequately studied. Investigation of the structural features that determine the mechanical properties of wood has hitherto been mainly concerned with the extent to which strength can be explained on gross anatomical grounds. These unexplained variations may, therefore, possibly be due to differences in the fine structure of the cell walls, the investigation of which calls for special refinements of microscopic and ultra-microscopic technique, and to the physico-chemical constitution of the wood substance which is not revealed by ordinary microscopic examination. The possibility of taking into account variations in the cell wall structure of wood fibres has recently been under consideration. Methods elaborated in the botanical laboratories of Leeds University may have a bearing on this problem, and with the co-operation of Professor J. H. Priestley and his assistants it is proposed to see whether the investigation of the strength of wood can be advanced by these methods.

For the sake of uniformity with previous work under this project, which was initiated to examine the fundamental relations between structure and mechanical properties, it has been necessary to concentrate attention on the maximum crushing strength parallel to the grain. In the case of ash, which is one of the timbers under investigation, probably the most important strength property is toughness (that is, its resistance to fracture under suddenly applied bending loads), and accordingly the project has been extended to cover a study of structure in relation to this particular property.

Tests of Timber in Structural Sizes

In the early part of the year the scope of this project was critically reviewed in relation to the very wide range of structural timber entering this country. In regard to the timber of Scots pine from northern Europe, with which the home market is principally concerned, the countries from which supplies are obtained

cover an area ranging in latitude from 37°N. to 70°N. and in longitude from 5°E. to 150°E. In view of the wide range of conditions which is to be found over so vast an area, considerable variation must inevitably result in the characteristics of a natural product such as timber. Such variation has, in fact, been recognised by importers and users in this country, and the timber from the various countries differs considerably in repute. In the absence, however, of information as to the relative merits of these timbers, based on systematic tests, opinion is naturally inconsistent.

This uncertainty is reflected in numerous enquiries concerning these supplies. Moreover, from the point of view of the Laboratory, it is a considerable handicap when the use of Empire substitutes is under consideration.

In view of this position it has been decided that the scope of the work should be widened to embrace the entire range of structural timber used in this country. The necessary schedule of material for tests has therefore been prepared, and steps are being taken to obtain the required quantities. The tests will be carried out continuously, and each consignment will be reported on as soon as the results are available.

During the past year the following material has reached the Laboratory for test :—

218 joists of Eastern Canadian spruce,
72 joists of Douglas fir,
168 joists of Scots pine from various North European ports.

The cost of this timber has been met by the Timber Trades Federation of the United Kingdom, which is actively supporting this work. The choice of sources of production was decided by the Laboratory and a sub-committee of the Council of the Federation acting jointly, and the pieces for test were selected by officers of the Laboratory from shipments in this country.

The tests were made at the standard moisture content of 15 per cent. This involved conditioning the timber, which reaches the Laboratory at a moisture content generally of the order of 28 per cent. As a result of this requirement the first of the material secured this year was not ready for test until late in the year. In the early part of the year tests were made on seasoned joists of Scots pine from Longleat, Wiltshire, and Douglas Castle, Scotland.

The first report under this project is expected to be issued early in 1935.

Improvement in Test Methods

A number of modifications have been made in the method of carrying out standard tests. In the first place, effect has been given to the recommendation of the Timber Mechanics Committee

whereby the measurement of certain properties has been discontinued. In some cases a characteristic of the timber was recorded by more than one property, and in other instances, notably where the limit of proportionality of stress to strain was involved, the property was deemed too vague to warrant retention.

The apparatus with which these tests are performed has been improved in a number of ways. In particular, for use in static bending tests, an improved form of support has been adopted and an autographic load-deflection recorder, which will also register resilience, has been designed. This latter instrument will eliminate most of the present lengthy process of plotting curves and integrating by means of a planimeter.

The layout of the cards on which the test data are recorded has been entirely re-designed, and considerable saving of time in the recording and computing of test results has been made possible.

Throughout the work of this Section, statistical methods are being used wherever possible for the planning of tests and the interpretation of results. At present the methods are being applied to such problems as :

(1) The estimation of variation in a set of observations.

(2) The estimation of reality or otherwise of differences in means between two or more sets of data.

(3) The evaluation of the best line to show graphically the relationship between two associated properties of the timber.

The Strength Properties of Timbers of Commerce

Considerable data have now been accumulated concerning the strength properties of the timbers of the world. When first recorded, however, much of this information was in a form which made further correction necessary before it could be used for direct comparison of timbers. For example, although the strength properties of wood vary considerably with moisture content below fibre saturation point, in many cases it is found that timber specimens tested air-dry have held moisture contents which have varied considerably from the standard of 12 per cent. The immediate value of such data for purposes of comparison is in consequence very greatly reduced. It is possible, however, by using the results of strength-moisture and other relationships, which have been investigated in the Laboratory, to make the necessary corrections to enable the results to be related to 12 per cent. moisture content. This has been carried out where necessary, and the standardised values are now available for immediate reference. Though there are at present considerable gaps in the information available, these are being filled as testing by standard methods proceeds.

Strength Properties of Home-grown Timber

During the year under review tests were made on timber from the following consignments that had been seasoned in the conditioning chamber to the standard moisture content of 12 per cent :—

Corsican pine (*Pinus nigra* var. *calabrica* Schneid.) from Filleigh, Devon ; Paddockhurst, Sussex; Dalbeattie, Kirkudbright ; and Denbighshire.

Norway spruce (*Picea Abies* Karst.) from Stourton, Wilts.

Silver fir (*Abies alba* Mill.) from Gosbury, Hants.

Scots pine (*Pinus sylvestris* L.) from Glenmaillie, Inverness ; and Butchall, Aberdeen.

Maritime pine (*Pinus Pinaster* Ait.) from Corfe Castle, Dorset.

Beech (*Fagus sylvatica* L.) from Temple Guiting, Gloucestershire ; and Arundel Park, Sussex.

Spanish chestnut (*Castanea sativa* Mill.) from the Forest of Dean, Monmouth.

Cherry (*Prunus Avium* L.) from the Forest of Dean, Gloucestershire.

A total of 57 consignments representing 21 species has now been subjected to standardised tests for the determination of their mechanical and physical properties. With the exception of one or two timbers of minor importance and of a small number of which further consignments will be taken to amplify existing data, this work may now be regarded as complete.

The investigation represents the first attempt at the systematic recording of the strength properties of home-grown timber. As a result of this work, it is now possible to compare these timbers on a definite basis and to determine their suitabliity for any particular purpose and the extent to which one timber may be substituted for another. The value of the results is greatly enhanced by the fact that the same methods of test are standardised in the principal forest products laboratories of the world, thus affording direct comparison between timbers grown in this country and abroad.

Strength Properties of Poles of Home-grown Timbers

The mechanical strength tests of home-grown poles, which were supplied by the Forestry Commission for investigation of their strength properties and capacity of absorption of creosote, have now been completed. The report of this work is in preparation and will be issued early in 1935.

Factors affecting the Resistance of Timber to Wear

Considerable work has been carried out in connection with the development of an abrasion test to enable the wear-resisting qualities of timbers to be determined, and definite progress has been made.

With the object of providing the necessary guidance as to the nature of the wear which should result in timber under test, a comprehensive study has been made of the condition of wood block floors subjected to widely differing kinds of traffic and after varying periods of service. As a result of this study, certain definite conclusions have been reached and attempts are now being made to develop the test accordingly.

Experiments have been made to determine the most suitable form of stud for the stamping component of the abrasion machine, the function of which is to loosen the surface fibres of the wood. Studs having hemispherical heads have been tried, but it was clear that these resulted in an altogether abnormal intensity of pressure, under which the wood was disintegrated to a considerable depth in a very short time. More satisfactory results were achieved by using cheese-head studs, although the cutting effect of the edges was rather severe in its action on the wood fibres. Cheese-heads with a rounded edge have therefore been tried, and achieved the desired results without any severe local effect. This latter form of stud has therefore been adopted as standard.

Experiments have also been made using various materials for the scuffing tool, the function of which is to rub off the fibres which have been loosened by the stamper. These materials have included various leather and rubber products as used for brake linings and also a form of steel shoe with a grooved head. The bonded asbestos product has been retained as most nearly meeting the requirements of the case.

The stage has now been reached where the results obtained on the machine are similar in many respects to those observed in timber in service. Certain timbers maintain a smooth surface whilst being worn down; others, notably softwoods converted so that the growth rings are parallel to the surface, fail by splintering and "shelling off" along the growth rings. These results are promising, but further trials will be carried out before the machine in its present form is finally adopted as satisfactory.

The final stage of the work will consist of the definition of the various types of failure and the adoption of standard criteria of serviceability.

Special Tests at the Request of other Organisations

Examples of the investigations undertaken during the year are :—

(1) Mechanical strength tests of a timber which a firm of importers was introducing into this country. The object of the test was to enable the characteristics of the timber to be assessed by comparison of its properties with those of timbers in common use.

(ii) Several series of tests for firms desiring to know the relative qualities of particular consignments of timber.

(iii) Mechanical strength tests of a number of home-grown and imported poles for another government department.
(iv) Tests to determined the relative qualities of two timbers for use as ship's decking.

A series of tests of sheet steel poles was carried out at the request of a firm of electrical engineers. Such work is outside the normal functions of the Laboratory, but the tests were undertaken in this instance as the pole testing equipment which is installed at the Laboratory represents the only equipment of its kind in the country. The equipment received a high measure of praise from British and foreign engineers who witnessed the tests.

Cricket Bat Willow

It was reported last year that an investigation had been commenced with the object of determining the properties of willow relative to use as cricket bats, in order to enable the most suitable types of willow for this purpose to be evaluated.

A number of bats manufactured from the willow which was collected in 1933 and air-seasoned at the Laboratory have been tested and reported on by professional cricketers. Mechanical tests will now be carried out on specimens cut from clefts matched with those from which the bats were made, and the results of the tests will be compared with the reports of the playing qualities of the bats.

In addition, the rebound of a cricket ball from these bats is to be measured and compared with the players' reports, in order to explore the possibility of employing a test of this nature for the assessment of the playing qualities of clefts previous to being made into bats.

Box Testing

The decision has been taken to proceed with the installation of the box testing plant which has been under consideration for some time. The plant will be housed in a separate building and will consist in the first instance of a small tumbling drum capable of taking containers up to a 2 ft. cube, and a crushing machine capable of exerting a force of 3,000 lb. and taking cases up to 3 ft. cube, together with certain small auxiliary equipment. The plant is expected to be in operation in the Spring of 1935*.

During the past year, several series of crushing tests of small fibreboard containers have been made at the request of manufacturers of these goods on machines temporarily adapted for the purpose.

Investigation of the Possibility of Deterioration from Staining in the Strength of Timber

The second series of tests, undertaken with the object of determining the effect of the staining fungus, *Ceratostomella cœrulea*,

* *See footnote page* 1.

on the strength properties of the sapwood of Scots pine, has now been concluded.

The experience gained from the initial investigation enabled more satisfactory growth of the fungus to be obtained, and useful results were achieved for periods of incubation up to six months. At this stage, although no reduction was apparent in strength under gradually applied bending loads, there was, nevertheless, a reduction of the order of 20 per cent. in the strength under such loads suddenly applied, together with a reduction of the order of 10 per cent. in hardness on the side grain.

After about six months, the test pieces became contaminated with a growth of moulds, and although this mould growth was probably without influence on the strength properties of the wood, it was felt that its presence would introduce an element of doubt into the results. The tests were therefore discontinued at this point.

Sufficient has been learned, however, to establish the desirability of investigating the influence of the fungus over extended periods. Consideration will now be given to the development of the technique necessary for satisfactory control of the conditions of exposure over such periods, to enable a series of tests to be carried out.

Effect of Decay on the Strength of Timber

It was reported last year that an investigation of the effect of *Polyporus hispidus* on the strength properties of ash had been undertaken. This work has now been completed.

The tests showed that the fungus reduces the strength and stiffness in static bending at approximately uniform rates, the reductions amounting to 36 per cent. and 15 per cent. respectively after 36 weeks' incubation. The maximum crushing strength was similarly affected, the reduction in this case reaching about 13 per cent. at the end of 24 weeks.

The strength under suddenly applied bending loads, generally described as toughness, was much more seriously affected. At the end of two weeks, before any discoloration or disintegration of the wood was evident, this property was found to be reduced by about 20 per cent. The reduction reached 40 per cent. after 4 weeks and 90 per cent. after about 15 weeks' incubation. The significance of these results lies in the fact that for most purposes for which ash is used, the toughness is the property of prior importance. The report on this work is now in preparation.

The Effect of Insecticides on Glues

Enquiries are received at the Laboratory from time to time relating to the effect of insecticides upon glues used commercially in the manufacture of furniture and plywood. Tests have been started to furnish information on this subject. Specially prepared

glued joints have been treated with various insecticides on the market for treatment of furniture or panelling attacked by wood-boring insects. Subsequently, the glue shear strength of treated joints will be determined and compared with that of untreated control joints.

Woodworking Research

Seven major scale and fourteen preliminary or minor scale investigations into the working qualities of home-grown and overseas timber have been carried out during the period under review. The behaviour of these timbers under normal working conditions has been ascertained, and where the necessity has arisen, experiments have been carried out to determine what modifications of the shape, setting or speed of the tools were required to obtain satisfactory working.

The scheme of research of which these investigations are a part has been revised, as the original project for this work did not provide for study of the fundamental principles of woodworking. It specified a series of controlled tests through which each timber should be passed, including in certain instances limited variation in the conditions of working, with the view to indicating if possible the most suitable type of tool and speed that should be employed for the particular species. Timbers are now being introduced into this country possessing peculiarities in grain arrangement or other feature requiring special treatment in machining or sawing, and more extended studies are necessary if the optimum conditions of working are to be determined in such cases. The technique for this must be based on knowledge of the principles underlying the working of timber—the influence of variables in the operations and of variations in the physical properties of a timber on its workability. A certain amount of information of this character has been collected during the last few years from major scale investigations under the original project, but its extent has naturally been limited. The revised project is intended to cover this fundamental research and will be followed so far as present laboratory equipment and staff permit. Extensions of these facilities are needed, however, to enable the full scope of the work to be undertaken in view of its value in application to commercial practice.

Study of the effect of variation of cutting angle on the finish produced in planing has been continued, and the optimum values of this angle determined for a number of timbers. The alteration in angle has been obtained by means of the special cutter block giving angular adjustment to the cutters, and with a surface planer having interchangeable blocks. It has been found that a cutting angle of 25° is generally the most suitable for hardwoods of medium density and fairly straight grain, whereas for those with wavy or interlocked grain a cutting angle varying from 20° down to 10° in very refractory cases is required.

Further work has been undertaken in connection with the sawing and machining of timbers containing silica and other abrasive substances. The most suitable shape and spacing of the teeth on ordinary plate saws to give a maximum life to the cutting edge with such timbers has been found. The experiments have shown, however, the need for specially tough and hard teeth tips with these timbers, and a saw tipped with Stellite—a tungsten carbide compound—is now undergoing trial. Tests are to be made at a later date with special steel alloy saws and, if necessary, the teeth of these will be heat treated to obtain additional hardness. The dulling of cutting edges in planing and other machining operations is another difficulty which is being investigated. A number of saw and cutter manufacturers have been approached on this subject and they have offered to co-operate in the work.

Investigations have been made of the working qualities of timbers in relation to specific uses such as box making, shuttle, bobbin and spool manufacture, battery separators, turned parts of furniture, etc. In certain cases these have necessitated the undertaking of surveys of the particular industries, and the collection of information concerning the timbers used, methods of manufacture and particulars of machines and tools employed.

Investigation of Home-grown Sitka Spruce

In view of the somewhat discouraging reports on the previous consignments of home-grown Sitka spruce tested at the Laboratory the Forestry Commission requested that the testing of a further consignment of timber considered to be more fairly representative of the species as grown under average conditions be undertaken. During the year a number of logs from three localities were received at the Laboratory for further tests. These were examined and reported upon in the round, converted to a schedule of sizes and allocated for woodworking and box-making trials. Woodworking tests were carried out along routine lines, and a parcel of boards representative of the different localities was forwarded to a London box manufacturer for trial and comment. Officers of the Laboratory visited the factory to witness the box-making tests, and to obtain first-hand opinions as to the suitability of the timber for this purpose. A report embodying the results of the wood-working and box-making trials will be completed early in 1935. A preliminary article[1] on the properties of home-grown Sitka spruce (on the lines of an interim report on the above test) has been prepared.

[1] Preliminary Note on the Timber of Home-grown Sitka Spruce (*Picea sitchensis* Carr.). *Forestry*, 1934, 8, 126–130.

Standard Tests on Wood Preservatives

Up to the present, the testing of wood preservatives has been carried out according to a standard method, which involves pressure application of the preservative to a large number of specimens for

field tests in order to obtain a reliable average result. The result of such tests will not be available for a number of years, and the preservatives tested under this scheme are limited to those that show considerable promise and are suitable for pressure application. Actually, there are appearing on the market an increasing number of preservatives, which are mainly intended for selling retail in small quantities for brush application. Frequent requests are made to the Laboratory either for tests of these preservatives or for information concerning them. Results of tests, if carried out on pressure-impregnated specimens, would not be available for a considerable time. Since most of these preservatives are sold for surface application, it is considered that satisfactory results could be obtained from tests on specimens treated in this manner, and they would be available at a much earlier date.

Tests have been started on these lines using specimens of beech and sapwood of Scots pine, both of which timbers are absorbent of preservatives and very susceptible to decay in an untreated state. A standard short-period dipping treatment is given and the specimens, together with untreated controls, are inserted in the ground at three different sites.

Tests on about thirty preservatives have been commenced. These tests on preservatives for non-pressure application are complementary to the standard tests on wood preservatives involving pressure application, which are being continued.

Railway Sleepers

The creosoted sleeper of Baltic fir at present in use in this country may be considered to give satisfactory service, its average life being from 18 to 25 years in a main line. The enormous quantity of timber used for railway sleepers, however, would justify investigating any possibility of cheapening the cost of the finished sleeper, even if the saving per sleeper were very small, or of obtaining a few more years of life at the same cost.

An investigation has been started with the object of :—

(1) Testing the suitability for railway sleepers of certain species of timber grown in the British Isles, and,
(2) Reducing the cost of a treated sleeper while maintaining or increasing the life.

Various methods have been suggested for attaining this latter object, but it is difficult to judge the efficacy of any method without actual trial. With the co-operation of the four main railway companies and the Forestry Commission, experiments have been started whereby sleepers of different species, treated in different ways, will be laid in the tracks for service trials. Of the home-grown species, Scots pine, Douglas fir, and beech have been included. The influence of different treatments and of incising will be studied,

and the experiment will also include tests on sleepers treated with mixtures of fuel oil and creosote and also with low temperature carbonisation creosote. In all, 4,400 sleepers are being treated and these will be laid in the tracks at eight different sites, and a record of their behaviour will be kept.

Fire Resistance Test

The laboratory testing of fire resistance of timber has been investigated on a small scale, and several methods of testing have been tried out. The method finally adopted consists of measuring the time taken for a standard blow lamp flame to penetrate a board of standard size, conditioned in air at a uniform temperature and humidity. This test has given fairly consistent results in preliminary trials, and distinct differences in the natural fire resistance of different species have been recorded. For example, the time taken to penetrate a $\frac{1}{2}$-inch board of teak was nearly twice that for oak and over four times that for western red cedar. A standard apparatus has been constructed, and tests on a number of different species in an untreated state are being carried out.

Small scale tests cannot compare in value with those made on complete constructional units, but they are useful in eliminating unsuitable timbers and indicating those likely to be worthy of major scale trials involving greater expense.

Mine Timber Durability Tests

The work of supervision and inspection of tests on the durability of mine timbers is being continued. Many of the untreated props originally installed in the mine have completely decayed, although the treated props remain practically free from decay. The tests have reached a stage where the advantage of preservative treatment is amply demonstrated, and it is proposed to publish a progress report in the near future.

Creosote

Work on the nature of creosote extracted from old creosoted timber has been continued, and an account of the results obtained has been published[1].

[1] Richardson, N. A. A Note on Creosotes extracted from Old Timbers. *J. Soc. chem. Ind., Lond.*, 1934, **53**, 710.

Field Tests on Natural Durability

The testing of the durability of various species of timber in an untreated state is proceeding. In addition to a number of Empire timbers, tests on several consignments of Baltic redwood from different ports of shipment have been inaugurated.

Damage Caused by Lyctus *Powder-post Beetles*

As in previous years, the Laboratory has been called upon for advice on methods of controlling and preventing damage by *Lyctus* in the premises of hardwood timber merchants, importers and manufacturers using susceptible woods. It is not surprising that losses are still being caused by these beetles, since, with the exception of a few of the more progressive firms, organised and co-operative action in the adoption of simple control measures has not been undertaken by the trade as a whole. Architects, builders, etc., can avoid trouble from these insects by specifying in their contracts the use of timber guaranteed free from *Lyctus*. Until such a step is taken by consumers, there is little real hope of materially reducing the losses caused.

The report on the results of the special enquiry, referred to in the last report, on the condition of Indian timbers with reference to *Lyctus* attack on arrival in this country, is now in the press[1].

[1] Cann, F. R. A Survey of Insect Damage to Indian Timbers in London. (*In the Press.*)

Factors affecting Lyctus *Attack*

Good progress during the year in the Laboratory's studies of the factors determining the susceptibility of timber to infestation can be recorded. For example, the account of the investigation into the relation between vessel diameter of a timber and its liability to attack, mentioned in the report for 1933, has now been published[1], and the results have already proved useful in affording an explanation of some of the problems encountered during work in Australia[2] upon the liability of the principal commercial hardwoods to *Lyctus* attack in that country.

[1] Parkin, E. A. Observations on the Biology of the *Lyctus* Powder-post Beetles, with special Reference to Oviposition and the Egg. *Ann. appl. Biol.*, 1934, **21,** 495.

[2] Cummins, J. E., and Wilson, H. B. The Pore Size (Vessel Diameter) of some Australian Timbers and their Susceptibility to Attack by the Powder-post Borer (*Lyctus brunneus* Steph.). *J. Coun. sci. industr. Res. Aust.*, 1934, 7, 225.

The Food of Lyctus *Larvæ*

(*a*) *Chemical investigation.*—In the report for 1933, reference was made to the isolation of a product from oak sapwood which resembled starch in some of its properties and which may well be the chief source of food for invading *Lyctus* larvæ. During the current year the method of isolating this substance has been improved, and a quantity sufficiently large for constitutional study has been prepared. It has been established that, under optimum conditions, approximately 90 per cent. of the material is converted to reducing sugars by takadiastase. The corresponding figure obtained for the soluble form of potato starch was 98.8 per cent.

The disparity between these results can only be explained by the presence in the product from oak sapwood of a small proportion of a substance, or substances, not affected by takadiastase. There are indications that the difference is made up of aldobionic acid residues. A relationship between the "starch" and hemicellulose A of oak sapwood thus becomes apparent, as it will be seen that the latter product has been found to be largely composed of anhydroxylose and uronic acid residues.

(*b*) *Biological investigation.*—A report on the results so far obtained on the biological investigation of the food relations of *Lyctus* larvæ is being prepared for publication. It has been confirmed that extraction of small samples of oak sapwood by water at 60° C. removes a substance the presence of which is necessary for normal larval development. In its absence, many larvæ die soon after hatching and those that live develop extremely slowly, being but little larger after tunnelling for 12 months than in their first stage, in spite of the presence of abundant starch in the wood. Extraction of similar samples with water at 100° C. removes the starch also and renders the wood totally unsuitable for larval development.

The importance of starch as food for *Lyctus* larvæ has been confirmed by demonstrating that they are unable to live in wood that is naturally starch-free and that in wood containing relatively little starch the life-cycle may be prolonged to two years or more, instead of being completed in the normal period of one year. It has also been shown that the female beetles are capable of detecting the suitability of timber for oviposition, in relation to its food value for larvæ.

Factors affecting Emergence and Flight of Lyctus *Beetles*

The investigation, begun in 1933, of the factors affecting emergence and flight of *Lyctus* beetles has been continued and extended. The insects do not normally take flight before dusk and can be attracted to artificial light. A trap was designed and constructed so that beetles attracted to a 60-watt bulb dropped into a glass vessel from which they could not escape. By a clock-driven mechanism the vessel was changed at pre-determined intervals, and a special tip-switch device switched the light on or off automatically as required. This trap was installed in an insectary well stocked with *Lyctus*-infested timber, and observations were made from June to September, the period of emergence of the beetles under out-of-door conditions. In addition, a special experiment was planned to determine the nightly emergence and deaths of beetles over the same period, in a small sample population kept under the same conditions as the material from which the beetles were trapped. This population factor is obviously of great importance since it determines the number of insects available for trapping in the insectary each night. From the catches recorded, it was found that the time of maximum activity of the beetles

varied and appeared to be related to the hour of sunset. Records were kept of temperature, humidity, barometric pressure, general weather conditions, and light intensity. A considerable amount of data has now been collected, but time has not yet permitted of its analysis nor of a statistical computation of the results.

Control of Lyctus

(*a*) *Kiln Sterilization Treatment.*—In 1933 work was started to determine the time required to kill larvæ in timber in a kiln at temperatures of 105° F.–125° F. and at a relative humidity of 60 or 80 per cent. The experiments were completed in 1934 and, except for anomalous results at 110° F. necessitating further work at this temperature, the duration of treatment for timber 1 in. or less in thickness has been ascertained. The following is a summary of the results, the times given not including any safety factor :—

Temperature °F.	Time required (hours) at	
	60 per cent. relative humidity.	80 per cent. relative humidity.
105	168	144
110	—	—
115	36	30
120	7	6
125	4	2

No conclusive result has been obtained for a temperature of 110° F., but the lethal period probably lies between 72 and 96 hours. When further information is available for this temperature, the full kiln schedules for sterilization of *Lyctus*-infested timber at temperatures ranging from 105° F.–130° F. will be published.

(*b*) *Log Storage.*—A new set of experiments to note the rate of depletion of starch in short lengths of winter-felled branchwood of oak, walnut and ash has been started. The investigation has now been in progress for twelve months, and the starch has not yet disappeared completely from the oak samples. No examination has up to the present (December 31st, 1934) been made of the corresponding specimens of ash and walnut. In continuation of the work on starch depletion in commercial-sized timbers in the log, further trouble has been encountered by decay of the sapwood when logs were left in the open, in spite of the bark being intact and the ends treated with creosote and sealed with tar within a few hours of felling. The sapwood of a 4-ft. length of oak about 20 in. in diameter was, however, successfully rendered starch-free in twelve months when treated as above, but kept under shelter. This result needs confirmation.

In co-operation with the Royal Small Arms Factory, Enfield, an enquiry was instituted into the possibility of utilising the iodine : potassium-iodide test for starch according to the method of Wilson[1] for segregating *Lyctus*-susceptible from immune stocks of hardwoods. An alternative method was elaborated by the Wood Chemistry Section of the Laboratory, and both were given a trial under the conditions at Enfield. It was, however, decided that on economic grounds both methods were impracticable.

[1] Wilson, S. E. Changes in the Cell Contents of Wood (Xylem Parenchyma) and their Relationships to the Respiration of Wood and its Resistance to *Lyctus* Attack and Fungal Invasion. *Ann. appl. Biol.*, 1933, **20**, 661–690.

Laboratory Tests of Wood Preservatives for the Prevention of Lyctus *Attack*

Work has been continued with a number of proprietary and other insecticides and preservatives to compare the duration of their toxicity in samples of oak sapwood by exposure to *Lyctus* attack. The experiments have been extended to include a number of water-soluble salts, with the object of finding a cheap preservative which could be used commercially for the prevention of *Lyctus* attack.

The Death-watch Beetle (Xestobium rufovillosum)

In the course of the past year further instances of damage by the Death-watch beetle to structural timbers in old buildings have been recorded, and there seems to be a general impression in the minds of those responsible for the care and maintenance of buildings that this insect has within the last few years suddenly become widespread in its activity. The evidence collected by the Laboratory, both from inspections of buildings and from the results of experimental work on the life-history and habits of the insect, does not support this belief. In the majority of instances of damage by this beetle, the date of commencement of attack is quite unknown, but the present state of the timbers, coupled with the slow rate of development of the insect under conditions normally present in the buildings, suggest that the injury has been progressing for many years. The apparent spread of the beetle can best be explained by the increased interest taken in its occurrence leading to inspections of old timbers through fear that the beetle might be present.

Furthermore, alterations to old buildings, which are now often being undertaken, may result in the discovery of Death-watch beetle damage, which otherwise might have remained unnoticed for many years. All the available information tends to confirm the belief that this insect has long carried on its depredations in old buildings and is now no more abundant, although more frequently detected, than in the past.

In view of present-day knowledge that the majority of old oak roofing timbers are likely to be in this condition, it is the responsibility of the present generation to do what it can to remedy the damage that it has inherited, bearing in mind that signs of injury do not always mean that the insect is still active or that the building is in a dangerous or unstable condition. Each individual case of Death-watch beetle damage requires careful examination and consideration to determine the control measures that are best suited to the conditions present. There is also the additional responsibility of ensuring that in years to come new buildings of the present day will not be liable to infestation by this insect.

How best to discharge these responsibilities must depend, first of all, upon a knowledge of the beetle itself, of its life-cycle, habits and food requirements. During the past year, therefore, although no investigations have been undertaken on the development of new methods of control, biological work has been continued and good progress can be recorded. For example, the rate and duration of egg-laying and the effect of varying conditions of temperature and humidity upon the incubation period of the egg—particularly important in relation to the rate of development of the insect in heated as compared with unheated buildings—have now been determined. The most important advance in the Death-watch beetle investigation, however, is the rearing of the beetle from egg to adult for the first time. So far as published accounts record, this insect has never been reared in any laboratory nor has the duration of its life-cycle been determined under different conditions of temperature and humidity. In the last annual report it was stated that the duration of the life-cycle in decayed wood at temperatures of 20° C.–25° C. was not likely to be less than two years. Work during 1934 has shown, however, that in willow in an advanced stage of decay and of moisture content 18–20 per cent., at the above temperatures the insect completed its development in the remarkably short period of 11 months. The results of experiments, carried out over the past four years in incubators and in the experimental house at the Laboratory, lead to the general conclusion that in a suitable timber, such as oak or willow, the length of life-cycle[1] of *Xestobium* depends upon :—

(*a*) condition of the timber with reference to fungal decay,

(*b*) moisture content of the timber, and

(*c*) temperature conditions,

and lend valuable support to the view that the development of *Xestobium* in buildings is extremely slow, unless conditions unusually favourable for rapid decay of the timber are present.

Now that the insect can be reared in the Laboratory, further work has been planned with the object of investigating the type and extent of fungal decay in timber in relation to the development

of the insect. Moreover, with the increased possibility of rearing large numbers of insects, investigations of various methods of control now become more feasible.

(1) FISHER, R. C. Duration of Life-Cycle of the Death-watch Beetle, *Xestobium rufovillosum*. (*In the press.*)

Heat Treatment for the Destruction of the Common Furniture Beetle (Anobium punctatum)

Work has been continued upon the determination of temperatures lethal to the different stages of the Common furniture beetle and the duration of treatment required. Earlier experiments with larvæ removed from the wood have shown that temperatures of 122° F. and 131° F. are lethal with an exposure of five minutes, but it is now apparent that the eggs of *Anobium* are more resistant than the larvæ. A treatment of twenty minutes duration at 131° F. was required for their destruction, and one of five minutes was found to be effective at 140° F. The above experiments were carried out under conditions of 30-35 per cent. relative humidity.

Pin-Hole Borer Damage to Empire Timbers

Reference has been made in previous annual reports to the damage that is frequently caused by Pin-hole borers to timbers from tropical countries and to the need of preventing this type of defect in Empire timbers for the markets of this country. The Laboratory has again urged the necessity for research on Pin-hole borers in the countries of origin of the timbers concerned and has continued to supply such information as is at present available on methods of prevention and control. The subject has on frequent occasions been discussed with Forest Officers and others visiting the Laboratory. At the request of the Conservator of Forests, Trinidad, insects collected from *Mora excelsa* Benth. were identified with the assistance of the Natural History Museum, and notes were supplied on their distribution. This information was required in connection with investigations recently undertaken by the Forest Department in Trinidad on methods of preventing damage by Pin-hole borers and other insects. A similar report was prepared on the insects found in a consignment of logs of Banak (*Virola merendonis* Pittier) sent from British Honduras to Princes Risborough for test.

The opportunity was taken during the past year of utilizing a number of elm trees, due for felling, to carry out at the Laboratory preliminary experiments on the technique of introducing preservatives into living trees with the object of exploring the possibility of developing such treatments for protecting the timber, when felled, from Pin-hole damage. The results of this work are not yet available but, if satisfactory, it is hoped to arrange for experiments to be undertaken in countries where Pin-hole borers are abundant.

Investigations of the Clothes Moth Repellent Properties of East African Camphor Wood (Ocotea usambarensis *Engl.*)

At the request of the Laboratory, a preliminary series of experiments was undertaken by the Wool Industries Research Association, Leeds, to determine whether East African camphor possessed any special moth-resisting properties and might prove suitable for the lining of cupboards, drawers, etc. The result of this work indicated however, that the timber did not appear to have any marked properties in this direction. Further investigations were not considered necessary, and the work was discontinued.

Sirex *Wood Wasps and Fungus Association*

In view of the mycological work that has been carried out at the Laboratory on this subject, it was arranged with Dr. R. N. Chrystal of the Imperial Forestry Institute, Oxford, that the entomological investigations formerly carried out at Oxford should be continued at Princes Risborough. A supply of *Sirex*-infested timber was obtained from Norfolk, through Dr. Chrystal, and the investigation is being carried on as time permits.

Detection of Wood-boring Insects by Radio-valve Amplification

An investigation has been started in co-operation with the Radio Department of the National Physical Laboratory to determine the possibility of using radio-valve sound amplification for detecting the presence of wood-boring insects in timber. An amplifier was constructed for use at Princes Risborough, and the results of preliminary tests showed that although the method could usefully be developed for application in the laboratory, it was unlikely to be of practical use in a building (for instance, in the detection of larvæ of the Death-watch beetle in roofing timbers), owing to the difficulty of eliminating extraneous noises.

Identification and Physiology of Wood-destroying Fungi

Further additions have been made to the collection of standard cultures of wood-destroying fungi, and also to the herbarium of sporophores. Numerous requests for cultures have been received, and by an arrangement with the Curator of the National Collection of Type Cultures at the Lister Institute, cultures of Basidiomycetes can now be supplied in response to requests received at that Institute. In this way, unnecessary duplication of type collections is avoided.

Research on the physiology of the fungi that attack wood has been continued. The temperature relations of a further number of species have been determined, and in connection with this work an electric refrigerator has been installed in which the temperature can be accurately controlled, and in which the lower limits for growth of the fungi can be determined. A paper containing the results, graphically illustrated, which had already been obtained with a number of important species, was published during the year[1].

The changes in hydrogen ion concentration that occur in media on which wood-destroying fungi are growing are being followed. It has been found that entirely different results may be obtained when the medium is wood, and when it is a nutrient liquid in which the food supply can rapidly become exhausted, so that deductions concerning pH. from experiments on artificial media must not be applied unreservedly to the conditions of growth in wood.

The effect of slight attack by a fungus of the type that causes heart rot in the standing tree upon the subsequent susceptibility of the timber to decay by fungi of the dry rot type is being further investigated. Similarly, tests are being made to discover whether there is any basis for the commonly made assertion that wood discoloured by a staining fungus of the *Ceratostomella* type is more liable to rot than clean unstained wood, and experiments, both with naturally blue-stained material and with timber artificially infected by staining organisms, are in progress.

A paper containing the results of work upon the effect of increased nitrogen upon the rate of decay of timber has been published[2].

[1] CARTWRIGHT, K. ST. G., and FINDLAY, W. P. K. Studies in the Physiology of Wood-destroying Fungi. II. Temperature and Rate of Growth. *Ann. Bot., Lond.*, 1934, **48**, 481–495.

[2] FINDLAY, W. P. K. Studies in the Physiology of Wood-destroying Fungi. I. The Effect of Nitrogen Content upon the Rate of Decay of Timber. *Ann. Bot., Lond.*, 1934, **48**, 109–117.

Dry Rot Investigations

The exceptionally dry conditions during the summer of 1934 were unfavourable for the development of dry rot in the experimental house, and owing to a general drying out of the sub-soil, conditions became too dry for fungus growth, even in the badly constructed floors.

The first experiment with various types of solid floors has been concluded. After the floors had been examined and the moisture contents determined, they were removed. A new series has been laid down, in which the boards are nailed to creosoted fillets embedded in cement, over which is a thick layer of bitumen. The fillets have been treated by full-cell and open-cell pressure creosoting, and by a dip treatment with creosote. Results of the first experiment showed that the only type of solid floor that is satisfactory is one that includes some effective damp proof course between the concrete and the boards, and that probably this is best provided by a thick layer of poured bitumen directly under the boards. A Laboratory report summarising the results so far obtained will shortly be prepared.

Decays of Oak Timber

Further study has been made of the principal fungi responsible for decay in oak timber, and numerous photographs of typical rots

and of the fruit bodies *in situ* have been obtained. The descriptions are being prepared, and since the literature on this subject is very scattered and mostly in foreign periodicals, it is proposed to include a brief survey of previous work on the fungi concerned.

Further records of the fungus provisionally identified as *Fomes cryptarum* have been made. It is evidently fairly widely distributed and is capable of causing serious decay under favourable conditions. A detailed description of this fungus and its effect on wood has been prepared. It is of interest to note that wood decayed by this fungus is very readily attacked by the Death-watch beetle, and in the biological studies of this insect, it has been found to be the most suitable fungus for bringing the wood into a condition suitable for the development of the insect.

The fungus responsible for the development of " brown " oak has been identified and studied in culture. A tree bearing sporophores of the fungus was felled near Radley, Oxfordshire, and on conversion this was found to be completely " brown " from the butt up to the first fork about 12 ft. above. It appears that the fungus spreads very slowly in the trunk, and it is planned to carry out some inoculation experiments to determine how quickly it can spread. A preliminary experiment has shown that infection takes place quite readily if small plugs of wood containing living fungus be inserted into the heartwood. A full account of the investigation has been written and will shortly be published.

Chemical Action of the " Brown " Oak Fungus on Oak Heartwood

A chemical investigation of the effect of the fungus on oak heartwood is in progress. The view has already been expressed by Groom [1] that tannin is used as a food material, but the chemical evidence submitted in support of this view is not convincing. Analyses have shown that " brown " oak may have a slightly lower tannin content than normal oak, but the differences actually found might well be accounted for by normal variations in the tannin content of the species. Of greater significance is the fact that in the specimens examined, the proportion of tannins to non-tannins is lower in the " brown " oak. This suggests some action by the fungus on the tannin, the mechanism of which has not yet been established, but, in addition, a certain amount of evidence has been obtained which indicates that the fungus may also act upon the major wood components. This view is supported by microscopical observations and the results of mechanical tests.

[1] Groom, P. "Brown" Oak and its Origin. *Ann. Bot., Lond.*, 1915, **29**, 393.

Strength Properties of " Brown " Oak

A further series of mechanical tests has been carried out on material from the Radley tree, and a note describing the results has been published[1].

The tests showed that the density of the wood, although low, was within the range of density of ordinary oak as obtained from previous tests. The strength properties, on the other hand, proved to be of a lower order than those of normal oak of equal density, the " brown " oak being markedly softer and more brittle.

No difference in strength was detected in the previous tests made on ordinary oak and " brown " oak samples cut from a partly discoloured board. Since this first test material was only partly discoloured, however, it was considered probable that the fungus had been working in the wood for a much shorter time than in the case of the Radley tree, the heartwood of which was completely brown.

On this evidence it appears probable that the action of this fungus, which is of the wood-destroying type, is slow in the early stages of infection. Further tests will be made to verify this finding.

(1) LATHAM, J. and ARMSTRONG, F. H. The Mechanical Strength Properties of " Brown " Oak. *Forestry*, 1934, **8**, 131.

Fungal Staining of Timber

Serious loss is sometimes experienced owing to staining of timber caused by the growth of moulds and similar fungi, and as this often occurs during transport, it leads to heavy claims against shippers. A large amount of timber is shipped in a more or less green or only partly seasoned condition, and during the course of a long voyage considerable deterioration may occur. A dip treatment of such timber immediately after conversion would probably prevent most of the fungal growth.

Several full scale experiments have been carried out to compare the efficacy of various chemicals for dip treatment. In the first experiment, two-inch boards of spruce were dipped as they came from the saw in solutions of various chemicals and were then stacked amongst untreated boards. Owing to a spell of very dry weather immediately after stacking, little staining occurred, even in the untreated boards, so the experiment has been repeated. In the second experiment two-inch planks of Corsican pine were piled immediately after conversion in September, with air spaces only ½in. deep between the layers (Fig. 6). A copious growth of mould has developed on the untreated control boards, which are already heavily stained, so that the treated boards, which are intermingled with them, are being exposed to a severe test. The pile will be dismantled early next summer, and the value of the various " dip " treatments for preventing stain assessed. Considerable differences are already apparent.

Laboratory Tests on Natural Durability

The resistance to dry rot and other types of fungal decay of a further number of timbers, both home-grown and colonial, has

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FIG. 6.—*Experimental Stack of Corsican Pine Timber*

One half of the boards treated with various chemical dips against fungal staining. Note the development of mould and sap-stain on the alternate rows of untreated boards, and the narrow stickers designed to encourage staining.

been examined. Amongst those that have given indications that they possess a high resistance to decay may be mentioned—black cabbage bark, *Lonchocarpus Castilloi* Standl.; iroko, *Chlorophora excelsa* Benth. and Hook. f.; okan, *Cylicodiscus gabunensis* Harms.; and mninga, *Pterocarpus angolensis* C. DC.

The durability of timber cut from logs of oak and beech stored under sea water is being compared with that of air-dried material.

A number of tests upon the resistance to dry rot of various building materials, such as wall boards and insulating materials, have also been carried out.

Staining of Paint Films

In order to discover a suitable toxic agent that can be added to paint to prevent any subsequent growth of mould fungi, tests have been made upon a number of substances. The problem is one of some difficulty, as the oil in the paint appears to render inactive the greater part of any toxic substance that is added. Many antiseptics are excluded on account of their early evanescence or on account of their effect on the setting of the paint film. Further tests are in progress, and the relative liability of various types of paint to mould growth is being examined.

The Action of Calcium Salts on Wood

Within recent months a considerable amount of publicity has been given to a series of researches [1] which have been undertaken to indicate that, under certain natural conditions, structural timbers undergo a form of insidious chemical disintegration that is entirely independent of the action of organisms. The decomposition is supposed to be initiated by the interaction of salts, such as calcium bicarbonate, with the cellulose of the wood, and the further claim has been made that, in nature, a process of inorganic ionic intrusion precedes most forms of organic decay of wood. The results of the researches in question have been critically examined, and where possible experimental work has been repeated. Particular attention has been devoted to the action of calcium carbonate on wood in the presence of carbon dioxide, and from results already obtained there are no indications that the reactions which take place involve other than certain minor constituents of the wood, such as tannins and related bodies. As to the view that most forms of organic decay in nature are preceded by the reaction of certain inorganic compounds with the cellulose of the wood, it need only be stated that fungi have repeatedly been shown to be capable of attacking wood *per se* under conditions suitable for their growth and development.

[1] Rudge. *J. Soc. chem. Ind., Lond.*, 1933, **52**, 283T, 447T; Ibid., 1934, **53**, 37T, 125T, 208T, and 282T.

The Effect of Chemical Reagents on Wood: The Lignin Determination in Wood Analysis

The work on the effect of sulphuric acid on wood substance, with special reference to the technique of the analytical determination of lignin, has been continued. A cold chamber has been installed so that digestion with 72 per cent. acid can be carried out at a constant temperature. A series of experiments has been carried out with the object of examining the many variables involved in the lignin determination, and as the work proceeds, it is hoped to determine a set of conditions under which the yield of lignin is reduced to a minimum without loss of methoxyl groups and under which the formation of carbohydrate condensation products is, as far as possible, avoided.

The Hemicelluloses of the Wood of English Oak

Further progress has been made in the study of the composition and properties of hemicellulose A isolated from samples of oak wood dried under various conditions. The results, which have been published [1], show that, although drying of the parent wood substance at moderate temperatures results in lower yields of hemicellulose A than are obtained from the green wood, the composition of the product is remarkably uniform. Degradation of the sapwood product was observed when the parent wood substance was dried at temperatures exceeding 40° C., but the heartwood product was apparently stable at temperatures up to 100° C. Anhydro-xylose residues constitute the greater proportion of oak hemicellulose A, and these are combined with a proportion of uronic and methoxy-aldobionic acid residues. The former acid residues predominate in the sapwood product, and the latter in the heartwood product. There are indications that the transition from sapwood to heartwood is marked by definite constitutional changes in the hemicellulose A. The interesting observation has been made that the sapwood product gives the blue coloration with iodine that is characteristic of starch, whereas the heartwood product does not.

[1] O'Dwyer, M. H. The Hemicelluloses of the Wood of English Oak. II. The Composition and Properties of Hemicellulose A., isolated from Samples of Wood dried under various Conditions. *Biochem. J.*, 1934, **28**, 2116–2124.

Grading

Practical classification studies, carried out on semi-commercial lines, form an important part of the Empire timbers investigations. Grading on a basis of standard rules furnishes an analysis of the yield and value of the timbers investigated, and also gives some indication of their potential market value in competition with others, already well established. Grading may also indicate the advisability of adopting measures to prevent or minimise degrade

through such causes as stain or borer attack. The information obtained in grading studies is therefore of value to shippers and others concerned in establishing markets for new timbers or those concerning which little information is available.

Utilization of Thinnings

The profitable disposal of thinnings of certain species has always been a difficult problem, and in the future when there will be hundreds of thousands of linear feet of such material available from the plantations of the Forestry Commission and private owners throughout the British Isles, it is likely to become acute. The manufacture of pulp and wallboard appears to offer one solution, and certain preliminary steps have been taken in an investigation to determine whether industries can absorb the thinnings. Pulp manufacturers and firms making wallboards have been interviewed, and data collected from these and other sources as to the nature and specification of the raw material used in these industries. In collaboration with an important pulp-grinding firm, and with timber-growing bodies, an investigation is being made into the suitability for pulping of home-grown timber from different localities and grown under different conditions. This project will be continued throughout 1935.

Mining Timber

The employment of imported timber for the greater proportion of pit-wood used in the pits in Great Britain is a matter of concern to timber growers in many parts of the country, and though high railway freights may be largely responsible, it is undoubtedly true that the quality of the pitprops sometimes offered by home suppliers falls short of that of the imported material. With a view to demonstrating this, visits were paid to H.M. Inspector of Mines, Birmingham, the Cannock Chase Colliery, the Hamstead Colliery, and an official of the Safety in Mines Bureau. A range of sample props was obtained, including various sizes and qualities of imported props, and these, when compared with samples of the home-grown article, demonstrated the higher standard of the props from abroad, which is attained by careful preparation of the props and attention to market requirements. There is no reason why a similar standard should not be attained in the home-grown product if the same care were taken. From this investigation much useful information as to specification, prices, mode of use in the pits and so on was collected, and this, together with certain other data already in the Laboratory's records, was assembled in a more concise form. A glossary of the terms used for mining timber in different districts, containing illustrations of the different usages, was compiled for future reference and has been placed at the disposal of enquirers.

Turnery

During the year visits were made to thirty-four firms engaged wholly or partly in turnery. This work was planned as part of the general programme of utilization studies, but was also arranged so that it would be of direct assistance to the Forestry Commission in the Survey of the Home Timber Industries, which will be continued during the coming year. A questionnaire to be used on these visits was formulated, and has been adopted as the basis of the form to be used by the Commission. Information was collected as to the source of the timber at present used, the specification required, the class of article manufactured, and other particulars relevant to the main issue—the possibility of utilizing home-grown or Empire woods in the turnery industry.

Co-operation Work with Public Authorities, Professional Associations and Government Departments

Co-operation with public authorities, professional associations and government departments in arranging and carrying out various tests, in visits of inspection and in supplying information continues to play an important part in the work, and thereby many valuable contacts are made. The goodwill manifested in these investigations increases the value of the work, and enables trials to be carried out for which there are no facilities within the Laboratory itself.

Forestry Commission Pruning-saw Investigation

At the request of the Forestry Commission, trials were carried out on Mathieson curved pruning-saws, to determine the most suitable gauge, shape, teeth and setting for pruning work with pole saws in the field. It is considered desirable to obtain as smooth a sawn surface as possible to promote speedy occlusion, and the ease or otherwise of sawing is an important factor in the cost of the operation. After a series of tests carried out on four species, with pruning cuts at a height of about 15 ft., the saws being modified in several ways in the course of the tests, a final form was arrived at that was considered most suitable, both from the point of view of smoothness of cut and ease of working. The details of this were recorded in specification form and forwarded to the Forestry Commission as a model for further field trials.

Effects of pruning Trees on the Quality of the Timber

The practical and economic possibility of producing higher grades of timber by pruning standing trees is a question of the first importance to foresters and timber growers. The silvicultural aspects of this problem are being studied in the field by the Forestry Commission in a comprehensive working plan, and the Laboratory is making examinations of the results of pruning. These latter cover the rate at which occlusion takes place and the extent of

grain disturbance, and also the improvement in grade that may be expected in lumber from trees pruned at various ages and to different heights. The first is to be achieved by the examination of actual pruned material, and the second by a comparative grading of trees on the assumption that prunings had taken place at different ages and to various heights. By this means it will be possible to ascertain both the probable financial results of the pruning and the best method of carrying it out.

During the year a number of logs of pruned material have been examined and unpruned logs graded, the results being subsequently analysed and tabulated, and suggestions made with regard to the Commission's Pruning Working Plan. Arrangements have been made for the supply of further material for examination during 1935.

Commercial Reports on Home-grown Timbers

Commercial reports were prepared on all consignments of home-grown timber dealt with by the Seasoning Section. The logs were inspected and photographed on arrival, the converted material was examined as it came from the saw, and again after air- or kiln-seasoning. After disposal of the seasoned timber to commercial firms, wherever possible a visit of inspection to the buyers was made, to obtain a final opinion on the quality of the various parcels.

During the year several consignments were reported upon, three of home-grown beech, one of Carpathian beech, one of chestnut, one of oak and one of Dutch elm.

The Permanent Exhibit or Museum

Hitherto the Exhibition Building has unavoidably been used as an assembling and packing house for successive outside shows and exhibitions at which the Laboratory has been represented, and consequently there has been little opportunity for arranging the numerous exhibits—many of them of considerable interest—in an orderly sytem. This work has been taken in hand during the latter part of the year. A tentative grouping of exhibits has been made, and it is hoped that early in the next year the building will be made to fulfil its proper function.

A special feature is being made of home-grown woods and utility and other articles made from them. The utilization of material, of both hard- and soft- woods, of small dimensions will be given prominence because of the urgent need for an outlet for this class of material.

The increasing demand for Empire woods for constructional and joinery work has led to the display of a number of these timbers. This exhibit has been supplemented by gifts from the Timber Commissioner for British Columbia, and Empire woods suitable for decorative and utility flooring have also been given special attention.

Glues in Woodworking

The increasing use of plywood has aroused much interest on the question of choice of glues and the technique of gluing. A note on this subject has been compiled with the assistance of members of the trade and circulated in the Laboratory for information.

An extremely interesting collection of different types of glues has been received for exhibition in the Museum.

Charcoal

From the number of enquiries received during the year, both from home and other sources, there appears to be a considerable revival of interest in charcoal production and the more intensive utilization of waste wood from timber fellings, clearings, and sawmills. Copies of blueprints of the Buchanan-Harris Portable Charcoal Kiln were distributed to enquirers seeking information regarding the production of charcoal in portable kilns, together with notes on the operation of such kilns and records of the results obtained with this type of kiln.

Drawings for a permanent brick-built charcoal kiln were prepared in response to an enquiry from British Guiana, these being so designed as to be adaptable to kilns of large or small dimensions.

Courses of Study for Attached Officers

Seven overseas forest officers have been attached to the Laboratory during the year for varying periods of study. The courses for these officers have been arranged to meet the special requirements of the officers concerned. In addition to studies of Laboratory routine work, special attention has been given to grading and woodworking methods. Literature and other written notes have been supplied.

A large number of visits to timber merchants, sawmillers, port and dock authorities and wood-using interests have formed an important part of the courses, and these enabled the officers to familiarise themselves with the conditions prevailing in the British timber market.

Photography

The work in the Photographic Section has greatly increased during the last year, as is shown by the following figures :—

	Negatives made.	Micro-negatives.	Photo-prints.	Lantern slides.	Opalo-graphs.	Blue prints.
1933	1,959	120	7,957	139	5,979	1,420
1934	2,413	346	10,574	225	6,325	1,913

A start has been made in the production of a cinematograph film demonstrating the testing of timber in structural sizes. Five hundred feet of 16mm. film have been made with satisfactory results, about 70 per cent. being suitable material for exhibition. A further seven to eight hundred feet has still to be made. In connection with this work enquiries have been received from outside interests for films for lecture work, and it is practically certain that the hiring fees of these films could be made to cover the cost of production.

Work for outside bodies has been executed on repayment terms.

A large number of transparencies and photo-enlargements have also been made in connection with the Bath and West Show, Oxford; The Empire Forestry Association's exhibitions at (1) the Royal Agricultural Show, Ipswich, and (2) the Highland Agricultural Show, Glasgow; and the Building Trades Exhibition, Olympia.

III. ADVISORY WORK

General Advisory Work

Year after year the general advisory work continues to increase. In the past year, in addition to various government departments, the London Passenger Transport Board and many private firms have sought and received advice.

Purely technical matters have been dealt with in the various sections of the Laboratory, and brief details of the advisory work done by them are given below.

Wood Structure

The volume of advisory work has been greater than in any previous year. It has been concerned chiefly with identifying timbers of all sorts and conditions, reporting on defects and supplying other information of a general botanical nature. Over 70 per cent. of the enquiries from outside sources was received from brokers, timber merchants, architects, builders and industrial concerns, the remainder being divided between government departments, public services, educational and research institutions and private individuals. Members of the staffs of universities and technical schools have made use of the Laboratory's facilities for the specialised study of wood structure.

Advice on the micro-technique of examining wood for special purposes has also been supplied to commercial firms.

Seasoning

There was a further increase of 45 per cent. in the number of enquiries pertaining to seasoning during the year under review. Over 80 per cent. of these was from trade sources asking for advice and assistance in practical problems connected with kilns, drying, steam-bending and the moisture relations of timber.

Timber Mechanics

The requests for information concerning the mechanical properties of timber have again been very numerous. With increasing knowledge of the facilities offered by the Section for the supply of such information there has been evident a growing interest not only in the absolute and relative strength values of timbers from both Empire and foreign sources, but also in their resistance to wear when used as flooring and for similar purposes.

Woodworking

The information gained from the wood-working studies at the Laboratory has been made available to the timber trade generally by means of articles in the technical press, the issue of notes describing the best methods of working certain timbers, lectures and advice tendered in response to enquiries. The latter have included problems arising with straight-line edging saws, drills, and portable cross-cutting machines, the finish of mouldings, the sawing and machining of greenheart, Australian walnut, African walnut, Canadian birch, western red cedar, Douglas fir and other timbers.

In addition to such circulation of information, many demonstrations in connection with woodworking practice and test technique have been made to members of the timber trade, technical students, architects, builders and others interested.

Wood Preservation

Advisory work on preservatives and methods of preservation continues to occupy a considerable part of the work, and a number of colonial forest officers and others have spent varying periods in the Laboratory undergoing instruction.

Entomology

During 1934 there has again been an increased demand for the services of the Laboratory for advice on problems arising out of insect damage to timber. The Entomology Section has been requested to carry out inspections of nineteen buildings, in most cases attacked by the Death-watch beetle, in order to advise on methods of treatment. Advisory correspondence has also increased, a total of 555 enquiries having been dealt with during the year. Apart from a large number of enquiries from private individuals concerning the Common furniture beetle, the majority came in almost equal numbers from architects or surveyors, and from timber importers or merchants. The remainder originated from builders, manufacturers using timber, government departments at home and overseas, church authorities and others. Of the records of insect-damage obtained from this advisory work, the following are worthy of special mention :—

1. The Longhorn beetle, *Hylotrupes bajulus*, a serious pest of seasoned softwood roofing timbers in North European countries,

has been recorded[1] during the past year from three buildings in widely separated districts in the South of England. In view of the quantities of softwoods used in house and other constructional work, the possibility of *Hylotrupes* spreading and causing extensive damage to structural timbers in this country cannot be overlooked.

2. The second record refers to the occurrence of the beetle *Nacerda melanura* (Oedemeridæ), the so-called "wharf-borer," which is known to cause considerable injury in harbours in the United States, where it occurs in the decayed portions of piling and other wharf timbers frequently immersed in sea water. During the year, the attention of the Laboratory has been called to a number of instances in which the larvæ of this insect have been involved, usually in timber which has been subjected to frequent soaking either by fresh or salt water and which is in a rotten condition. In one case, the insect was suspected of causing serious injury to a consignment of sound birch logs on arrival at the docks. Although definite information is lacking, it seems probable that *Nacerda* is usually associated with decayed wood and may be found abundantly in this country in the vicinity of piles or other woodwork in docks or warehouses. At the present time there is no evidence to show that it can be regarded as a primary pest of sound timber.

[1] PARKIN, E. A. The Occurrence of the Longhorn Beetle (*Hylotrupes bajulus*, L.) in England. *Forestry*, 1934, **8**, 150–154.

Mycology

The number of enquiries received again showed an increase over that of the previous year. The majority of these referred to decay in buildings, but an increasingly large number relate to the question of fungal staining in timber and plywood, and many concern the relative resistance to dry rot and other types of decay of various colonial and foreign timbers.

The prevention of decay in ships' lifeboats and in the wood lining of insulated ships' holds has been the subject of investigation. The problem is an important one and needs further research. Other subjects of enquiry include the protection of wood parts of aircraft against fungal attack in the tropics and preservation of motor car bodies against rot.

Utilization

Some four hundred and fifty-five enquiries of all kinds were received and disposed of during the year. It is gratifying to note that not only is the number of enquiries dealt with on the increase, but a good proportion of these is from the timber trade and from public bodies on problems of major importance.

Representation on Outside Committees

The Laboratory was represented on the following Committees :—

Standing Committee on Empire Forestry :—
(*Representative :* Mr. W. A. Robertson).

Empire Forestry Association :—

Governing Council
(*Representatives :* Mr. W. A. Robertson and Major J. R. Cosgrove, D.S.O., M.C.).

Exhibitions Committee
(*Representative :* Major J. R. Cosgrove, D.S.O., M.C.).

Trade Names Committee
(*Representative :* Major J. R. Cosgrove, D.S.O., M.C.).

Publications Committee
(*Representatives :* Mr. W. A. Robertson and Mr. H. A. Cox).

British Standards Institution :—

Building Industry Committee
(*Representative :* Major J. R. Cosgrove, D.S.O., M.C.).

Aircraft Technical Committee AC/2 on Timber, Glue and Casein Cement
(*Representative :* Mr. C. J. Chaplin).

Sub-Committee AC/2/1, Airscrew Timbers, Revision of Specification
(*Representative :* Mr. C. J. Chaplin).

Sub-Committee AC/2/2, Aircraft Plywood
(*Representative :* Mr. C. J. Chaplin).

Sub-Committee AC/1/9, Aircraft Timber
(*Representative :* Mr. C. J. Chaplin).

Sub-Committee on Transmission Poles
(*Representatives :* Mr. C. J. Chaplin and Mr. J. Latham).

Technical Committee B/10, Standard Definitions and Tests for Fire Resistance and Incombustibility
(*Representative :* Mr. N. A. Richardson).

Technical Committee B/14, Joinery
(*Representative :* Mr. C. J. Chaplin).

Technical Committee B/19, Unit Weights of Building Materials

(*Representative :* Mr. S. T. C. Stillwell).

Technical Committee B/24 on Timber

(*Representatives :* Mr. C. J. Chaplin and Major J. R. Cosgrove, D.S.O., M.C.).

Sub-Committee B/24/1 on Timber Grading

(*Representative :* Mr. C. J. Chaplin).

Revision Committee B/24/2 on Testing of Small Clear Specimens

(*Representative :* Mr. C. J. Chaplin).

Technical Committee C/1, Creosote for Wood Preservation

(*Representative :* Mr. N. A. Richardson).

Technical Committee for Standard Specification for Commercial Plywoods

(*Representative :* Mr. H. E. Kinns).

Technical Committee on Disinfectants

(*Representative :* Mr. K. St. G. Cartwright).

Imperial Institute :—

Advisory Committee on Timbers

(*Representative :* Major J. R. Cosgrove, D.S.O., M.C.).

Inter-Departmental Works Committee :—

Sub-Committee on Building Materials

(*Representative :* Major J. R. Cosgrove, D.S.O., M.C.).

British Wood Preserving Association :—

(*Member of Council :* Mr. W. A. Robertson).

Publications Committee (Co-opted)

(*Representative :* Mr. J. Bryan).

Technical Committee

(*Representatives :* Dr. R. C. Fisher, Mr. J. Bryan and Mr. W. P. K. Findlay).

Board of Education :—

Committee on Examination of Machinists

(*Representative :* Mr. P. Harris).

Forestry Commission :—

Advisory Committee on Forestry Research

(*Representative :* Mr. W. A. Robertson).

Utilization of Home-grown Timbers

(*Representatives :* Mr. W. A. Robertson and Major J. R. Cosgrove, D.S.O., M.C.).

Timber Development Association :—

(*Member of Council :* Mr. H. A. Cox).

Public Relations Committee

(*Representative :* Mr. H. A. Cox).

New International Association for Testing Materials :—

British Committee

(*Representative :* Mr. C. J. Chaplin).

Commission on Timber

(*Representative :* Mr. C. J. Chaplin).

City of London College :—

Timber Trades Advisory Committee

(*Representative :* Mr. W. A. Robertson).

IV. WORK FOR THE EMPIRE OVERSEA

Particulars of the investigations of the properties of Empire timbers which have been in progress during the year are given in Appendix II, in which there is reproduced the First Annual Report of the Standing Conference on Timber Utilization, which has been set up to promote contacts between the Laboratory, the timber trade, and the various parts of the Empire overseas which may make use of the facilities of the Laboratory for the investigation of the qualities of their timbers.

Some research work on colonial timbers has been carried out by officers of the Colonial Forest Service attached to the Laboratory for special training. The co-operation of the Imperial Forestry Institute in this connection is duly acknowledged.

APPENDIX I

LIST OF SCIENTIFIC AND TECHNICAL STAFF

Director of Forest Products Research : W. A. Robertson.
Assistant Director : F. M. Oliphant.
Administration Officer : A. R. H. Cox, B.Sc.
Scientific Officer II : H. A. Cox, M.A., Dip.For., Dip.Tim.Tech.
Scientific Field Assistant : A. N. David.
Publications and Records Officer : C. J. N. McCracken, B.A., Dip.For.
Assistant III (Photographer) : W. R. Hutchins.

Section of Wood Structure

Officer in Charge : B. J. Rendle, B.Sc., A.R.C.S.
Scientific Officer II : S. H. Clarke, M.Sc.
Junior Scientific Officer : E. W. J. Phillips, B.Sc., A.R.C.S.

Section of Timber Physics

Officer in Charge : W. W. Barkas, M.Sc.
Scientific Officer II : E. D. van Rest, B.A., B.Sc.

Section of Entomology

Officer in Charge : R. C. Fisher, B.Sc., Ph.D.
Scientific Officers II : F. R. Cann, D.I.C., E. A. Parkin, M.Sc., D.I.C.
Assistant III : E. C. Harris.

Section of Wood Chemistry

Officer in Charge : W. G. Campbell, B.Sc., M.S.
Scientific Officer I : Miss M. H. O'Dwyer, B.Sc., Ph.D., D.I.C.
Scientific Officer II : Miss K. F. Taylor, B.Sc., Ph.D., A.I.C.
Junior Scientific Officer : S. A. Bryant, B.A., B.Sc.

Section of Utilization

Officer in Charge : J. R. Cosgrove, D.S.O., M.C., M.E.I.C.
Scientific Officer I : P. Harris, B.Sc.(Eng.).
Assistant I : H. E. Kinns.
Assistants III : G. A. Donald, B.A., Miss E. C. M. Ernest, B.Sc., Ph.D., D.I.C.

Section of Seasoning

Officer in Charge : S. T. C. Stillwell, B.Sc.
Scientific Officer I : R. G. Bateson, B.A.
Scientific Officers II : R. A. G. Knight, B.Sc.(Eng.), A.M.I.Mech.E., W. C. Stevens, M.A., A.M.I.Mech.E.
Assistants III : R. E. Hodge, L. S. Doman, D. D. Johnston, R. J. Newall, N. Turner, G. H. Pratt.

Section of Timber Mechanics

Officer in Charge : C. J. Chaplin, M.Sc., M.E.I.C., M.I.Mech.E.
Scientific Officers II : J. Latham, B.Sc., F. H. Armstrong, M.Sc., A.M.I.Mech.E., Miss C. B. Pettifor, B.Sc., E. H. Nevard, B.Sc.
Junior Scientific Officer : H. Q. Golder, B.Eng.
Assistants III : Miss I. M. Elliot, B.Sc., A. J. Foord, R. H. W. Birkett.

Section of Wood Preservation

Officer in Charge : J. Bryan, M.Eng., A.M.Inst.C.E.
Scientific Officer II : N. A. Richardson, B.Sc., A.I.C.
Assistants III : D. N. Smith, R. J. Griffiths.

Section of Mycology

Officer in Charge : K. St. G. Cartwright, M.A., D.I.C., F.L.S.
Scientific Officer II : W. P. K. Findlay, M.Sc., A.R.C.S., D.I.C.
Assistant III : E. C. Badcock.

APPENDIX II

STANDING CONFERENCE ON TIMBER UTILIZATION

FIRST ANNUAL REPORT, YEAR 1934.*

The Department of Scientific and Industrial Research has agreed to hold available the facilities offered by its Forest Products Research Laboratory at Princes Risborough, under financial arrangements to be approved from time to time by the Department, for the investigation of the properties of particular timbers for various parts of the Empire overseas, and for furnishing such technical information concerning those timbers as may be of assistance in exploiting them.

It was therefore decided at the end of 1933 to establish a Standing Conference to act in a consultative and advisory capacity to the Department itself and to the various units of the Empire overseas which desire to make use of the facilities.

The Standing Conference determines its own constitution, arranges its own business and makes its own standing orders for its proceedings. (*See* pages 62 and 63). On the invitation of the Department, Sir John Stirling Maxwell, Bart., K.T., has consented to become Chairman of the Conference. The Conference contains members representing experience of the Timber Trade, other members appointed by the Department representing special experience or interest, and representatives of those units of the Empire overseas which make use of the facilities offered by the Laboratory. It receives reports from the Department and the members representing dominions or colonies, and may make recommendations to the bodies appointing members. The meetings of the Standing Conference provide opportunities of consultation among all those co-operating in the work of keeping the Department informed at first hand of problems arising in connection with exploitation or use of Empire timbers, and of promoting the practical application of the knowledge acquired during the investigations.

Meetings and Business Done

Meetings of the Standing Conference were held on July 3rd and November 20th, 1934. At the first meeting in July, rules and standing orders to govern its constitution and procedure were adopted, and a number of applications for the investigation of certain timbers from British Honduras, Trinidad and Uganda Protectorate were considered. It was also agreed that the newly formed Timber Development Association should be invited to nominate a representative for appointment to membership of the Standing Conference.

At the meeting in November the Standing Conference considered a report by the Department, supplemented by an oral statement by the Director of Forest Products Research, on the investigations which were in progress at the Forest Products Research Laboratory. It was reported that the High Commissioner for the Union of South Africa had applied for the assistance of an Officer of the Laboratory in determining whether the wood of a pine grown in South Africa was suitable for use for making boxes for the export of citrus fruits. The terms offered to the High Commissioner having been accepted, he had been invited to appoint a representative or representatives on the Standing Conference. The Director, Forest Products Research, reported that negotiations had been opened by the High Commissioner for Southern

* Being a report prepared by the Conference under Standing Order No. 9, which provides for the submission annually to the bodies appointing members of an Annual Report of the proceedings of the Conference. (*See* page 63.)

Rhodesia for tests to be carried out at the Laboratory to determine whether certain Southern Rhodesian timbers were suitable for use for the manufacture of pick handles. These negotiations are still proceeding.

The Conference has been able to make suggestions for the exploitation of a timber from Uganda Protectorate, and the Conservator of Forests has expressed his keen appreciation of the service rendered in this direction.

The experience already gained shows the meetings of the Conference provide valuable opportunities for the discussion of problems involved in the selection of Empire timbers for export, their conversion and grading, and of bringing together those specially interested in the subject.

January, 1935. JOHN STIRLING MAXWELL, *Chairman.*

REPORT BY THE DEPARTMENT TO THE CONFERENCE ON THE INVESTIGATION OF EMPIRE TIMBERS FOR THE YEAR ENDED 31ST DECEMBER, 1934.

The progress of the work of investigating the properties of Empire timbers during 1934 has been eminently satisfactory, and expressions of appreciation of the value of the reports on the tests and the information supplied to the timber trade and timber using professions and industries have been very numerous. Undoubtedly, a closer contact has been established between the Department's Laboratory at Princes Risborough and those interested in Empire timbers, and fuller use is being made of the facilities offered by the Laboratory than at any time previously. With the termination of the payment by the Empire Marketing Board for the work of investigating the properties of Empire timbers, and of supplying information useful in their marketing, the Empire Timbers Committee automatically came to an end. Fortunately, however, it was possible to make certain temporary arrangements for financing the work until such time as the recommendations of the Executive Council of the Imperial Agricultural Bureaux could be put into operation. As a result it was possible to avoid a cessation of the work with the attendant disorganisation which would have been entailed as a consequence.

Details of the various investigations which have been in progress during the year are given under the heading " Progress of the Investigations " on p. 57. Several lectures have been given on Empire timbers, and articles have also been supplied to various periodicals in response to requests received by the Director. These have served to supplement the advisory work carried out by the Laboratory.

APPLICATIONS FOR TESTS OF COLONIAL TIMBERS

In the course of the year 1934, the Standing Conference considered applications for the following investigations :—

Major Scale Investigation :—

Slash pine or British Honduras pitch pine : *Pinus caribaea* Mor. at the request of the Forest Department of British Honduras.

Preliminary Investigations :—

White olivier : *Terminalia obovata* Steud. from Trinidad.
Nargusta : *Terminalia excelsa* Liebm. from British Honduras.
Cramantee : *Guarea excelsa* H.B.K. from British Honduras.
Waika chewstick : *Symphonia globulifera* L.f. from British Honduras.
Cypress : *Podocarpus guatemalensis* Standl. from British Honduras.
Timbersweet : (Undetermined) from British Honduras.
Carbon : *Tetragastris Stevensonii* Standl. from British Honduras, at the request of the respective Forest Departments.

Special Investigations :—

For woodworking, seasoning and veneering tests of :—

Miovu : *Entandrophragma angolense* D.C. from Uganda.
Miovu : *Entandrophragma utile* Sprague from Uganda.
Mvule : *Chlorophora excelsa* Benth. & Hook f. from Uganda, at the request of the Forest Department.
Idigbo : *Terminalia ivorensis* A. Chev. from Nigeria, at the request of a firm in the United Kingdom.

The Standing Conference recommended that the investigations enumerated should be undertaken.

Contact with the Regions of Production

Towards the end of 1933, in response to a request from His Excellency, the Governor of Nigeria, arrangements were made for Major F. M. Oliphant to pay a second visit to Nigeria, and he sailed for West Africa early in January, 1934. He had arranged to devote about three months of the available time to further work in Nigeria, and afterwards to pay shorter visits to the Gold Coast and Sierra Leone. Unfortunately, owing to illness, Major Oliphant was obliged to return home at the end of his stay in Nigeria. The report on his second visit has been completed, and it is understood that it will be published by the Government of Nigeria as a Sessional Paper at an early date.

Progress of the Investigations

A. *Investigations Completed*

In the course of the year investigations of the following species have been completed and reports have been issued.

Major Scale Investigation

1. Munyama : *Khaya anthotheca* C.Dc. from Uganda

It is satisfactory to be able to report that, as a result of this major scale investigation, the useful properties of the timber have been demonstrated so effectively that active preparations for the exploitation of the species are now proceeding. It is confidently anticipated that, as soon as seasoned stocks have been accumulated, an export trade in the better grades will be developed, while the lower grades will find markets locally. To foster the development of such an export trade the Government of Uganda has enacted that the Forestry Department shall have power to prohibit the export of timber which in the opinion of the inspecting officer is not of sufficiently high grade to conform to the standard of quality required in the markets of this and other importing countries.

Preliminary Investigations

2. Podo : *Podocarpus gracilior* Pilg. from Kenya, *P. milanjianus* Rendle and *P. usambarensis* Pilg. from Tanganyika Territory

Preliminary investigations of the properties of the three species mentioned above were completed and a report was issued in April, 1934. The timber showed little or no variation in structure, seasoning and mechanical properties and working qualities as between one species and another. *P. usambarensis* appeared to have rather better steam bending properties than either of the other species, however. Podo was not durable when exposed to infection from wood-destroying fungi, but was easily impregnated with antiseptics such as creosote, which would prevent infection. The three species varied so little in their properties that for commercial purposes they might be treated as one timber. As a result of the investigation it is possible to say that Podo would be likely to prove satisfactory for good class joinery, handicraft work, foodstuff containers and utility turning.

3. Mninga : *Pterocarpus angolensis* DC. from Tanganyika Territory

A preliminary investigation of the properties of Mninga was completed in October, and a report on the results was issued in the same month. The timber appears to vary considerably both in colour and density. In spite of these variations, however, it seasons well, possesses satisfactory mechanical properties, works without any undue difficulties with machine and hand tools and has an attractive appearance. It can be veneered, and plywood faced with veneer of the timber has distinct possibilities for panels and decorative work. It should be suitable for shop-fittings, window-stands, display cabinets and furniture.

B. *Investigations in Progress at the Beginning of* 1934 *and Not Yet Completed*

Owing chiefly to the very slow rate at which the timbers have air-seasoned a number of investigations undertaken before the beginning of 1934 have still to be completed. These include the following :—

Major Scale Investigations

4. Ceylon gurjun : *Dipterocarpus zeylanicus* Thw.

This investigation is now practically finished, and it is anticipated that it will be possible to issue the final report early in 1935. An interim report was issued in August, 1934.

5. Mora : *Mora excelsa* Benth. from Trinidad

Although the material for this investigation was received as far back as March, 1933, and in spite of two dry summers, the stock which is being air seasoned is still insufficiently dry for laboratory tests on it to be undertaken. It is therefore proposed to complete the seasoning in one of the Laboratory's kilns. Some further service trials may possibly be undertaken when the seasoning has been completed.

6. Santa Maria : *Calophyllum brasiliense* var. *Rekoi* Standl. from British Honduras

This timber, like the previous one, air-seasons slowly, and the completion of the laboratory tests must await the reduction of the moisture content of the air-seasoning stock to 12 per cent. It is anticipated that it will be possible to carry out the remaining tests early in 1935.

7. Banak : *Virola merendonis* Pittier from British Honduras

As in the case of Santa Maria the process of air-seasoning has been slow. The stock of material for the laboratory tests is now nearly dry enough for the last stage of the investigation to be undertaken. It should be possible to complete the work in the first quarter of 1935.

Limited Major Scale Investigations

8. East African Camphor : *Ocotea usambarensis* Engl. from Kenya

Owing to the presence of an aromatic oil in this timber, it seasons very slowly, and this accounts for the fact that the investigation has extended over a period of two years. The laboratory tests are now practically complete, however, and it is hoped that it will be possible to report on the results of the investigation at the beginning of the coming year.

Preliminary Investigations

9. Yemeri : *Vochysia hondurensis* Sprague from British Honduras

This preliminary investigation of the properties of yemeri, begun in September, 1933, is now finished but for the writing of the report.

Special Investigations

10. East African pencil cedar: *Juniperus procera* Hochst. from Kenya

The work which has been and still remains to be done in solving the problems of softening East African pencil cedar and in seasoning it in such a way that warping of pencil-slats and pencils is reduced to a minimum has proved involved and extensive. The results already achieved were reviewed in the spring of 1934, and an interim report was prepared, following which it was possible to decide on new lines of research.

11. Queensland walnut: *Endiandra Palmerstonii* C.T. White

Material for the investigation of the working qualities of Queensland walnut arrived at the Laboratory in January last. The moisture content of the timber on arrival was in the neighbourhood of 60 per cent., and therefore seasoning was necessary before the tests could be undertaken, since the difficulty of working the timber increases very considerably as the moisture content decreases. It was possible to begin the work in October, however, and such progress has already been made as to warrant the assumption that it will be possible to issue a report in the early part of 1935.

12. Nigerian celtis: *Celtis Soyauxii* Engl.

Work on this species has, from various causes, proceeded slowly. The air-seasoning of the timber has proved to be a long process, but has recently been completed, so that it has now been possible to undertake the final Laboratory tests. It is anticipated that the preparation of the report will be undertaken almost immediately.

C. *Investigations Begun During* 1934

The following investigations have been started since the beginning of the year under review.

Major Scale Investigations

13. British Honduras pitch pine: *Pinus caribaea* Mor.

The application for the major scale tests on British Honduras pitch pine was considered at the first meeting of the Standing Conference on Timber Utilisation, at which it was agreed that it was advisable to undertake the investigation. The material for test, consisting of approximately 3,000 cu. ft. in log form, arrived at the Laboratory in the middle of August, and the conversion of the logs was started almost immediately afterwards. Seasoning tests both in kilns and in stacks in the open have been and, in the latter case, are still in progress, and tests of the mechanical properties of the green timber are also proceeding. Several firms engaged in the pitch-pine trade have sent representatives to inspect the timber, and the general opinion seems to be that there will be little difficulty in finding outlets for it.

Limited Major Scale Investigations

14. Opepe: *Sarcocephalus Diderrichii* De Wild. from Nigeria

Twenty-five logs, totalling about 1,000 cu. ft. in volume, reached the Laboratory in February. They were of very promising appearance, being of good diameter, clean, and in the majority of cases almost cylindrical. The work of conversion and testing was started without delay, and kiln-seasoning tests and tests of the mechanical properties of the green timber have been completed. Other laboratory tests are proceeding, and it is

anticipated that arrangements for testing the resistance of the timber to marine borers will shortly be made. As the moisture content of the air-seasoning material for the remainder of the tests of the mechanical properties and working qualities still exceeds 30 per cent., some time must elapse before they can be undertaken.

Preliminary Investigations

15. Okan : *Cylicodiscus gabunensis* Harms. from Nigeria

Three logs of Okan arrived at the Laboratory in January, and the work of testing the timber began in February. The kiln-seasoning tests have been completed, and also the tests of the mechanical properties of the timber in the green state. The remainder of the Laboratory tests can only be undertaken as the air-seasoning process is completed. The moisture content has now been reduced to the neighbourhood of 12 per cent., and therefore it should be possible to finish the investigation early in the forthcoming year. There has been one trade enquiry for this timber for ornamental turnery.

16. Odoko : *Scottellia coriacea* A. Chev. from Nigeria

Three logs of Odoko were received from Nigeria in February, and conversion was started without delay. On opening it, one log was found to be so defective as to be unfit for testing, and was rejected. Hence the material available was hardly sufficient even for preliminary investigations. The work of testing has been carried on as well as possible in the circumstances and is now almost completed. It is expected that a report will be issued early in the coming year.

17. White Olivier : *Terminalia obovata* Steud. from Trinidad

Five logs of White Olivier were sent to the Laboratory in October. As this species was formerly supposed to be the same as No. 18—Nargusta from British Honduras, it was decided to delay the tests until the arrival of the Nargusta so that they could be investigated side by side in order to determine whether there were any material differences or whether they could justifiably be regarded as one timber for commercial purposes.

18. Nargusta : *Terminalia excelsa* Liebm. from British Honduras

In December five logs of Nargusta arrived at the Laboratory. Owing to pressure of other work it was impossible to do more than carry out the conversion of the logs before the end of the year. The laboratory tests will be started at the beginning of January, 1935.

19. Cramantee : *Guarea excelsa* H.B.K.

20. Waika chewstick : *Symphonia globulifera* L.f.

21. Cypress : *Podocarpus guatemalensis* Standl.

22. Timbersweet : (undetermined).

A consignment, which included five logs of each of the above species, arrived at the Laboratory from British Honduras in December. As a consignment of home-grown beech, which required to be converted without delay, had arrived just previously, it was not possible to begin the tests of these timbers before the end of the year.

Special Investigations

23. Kenya olive : *Olea Hochstetteri* Baker.

In August a consignment of about 1,200 c. ft. of sawn material and three logs of Kenya olive was received at the Laboratory for special tests and service

trials to demonstrate, if possible, the suitability of the timber for use as flooring and for panelling and decorative work. The logs were converted and the seasoning of the whole of the material was undertaken as kiln accommodation permitted. Arrangements for certain service trials have been completed, and they will be undertaken early in the coming year.

24. Idigbo : *Terminalia ivorensis* A. Chev. from Nigeria

A small scale special investigation of the mechanical properties of Idigbo was undertaken in October at the request of a London firm of importers. The object of the investigation was to determine whether the timber possessed the necessary mechanical properties to warrant its application to the manufacture of motor bodies. A report on the results of the tests will be prepared at an early date.

25. Meranti pa'ang : *Shorea bracteolata* Dyer from Malaya

26. Melantai : *Shorea macroptera* Dyer from Malaya

27. Kempas : *Koompassia malaccensis* Maing. from Malaya

Special investigations of the working qualities of the above three species have recently been carried out at the Laboratory for the Forest Research Institute of the Malayan Forest Service. It is anticipated that the report on the investigations will be ready early in 1935.

28. *Pinus patula* Schl. & Cham. from South Africa

At the request of the High Commissioner for the Union of South Africa, consignments of oranges packed in boxes made of *Pinus patula* grown in South Africa were inspected on arrival in this country by officers of the Laboratory. This work was undertaken to determine whether fruit boxes of the native-grown pine were as satisfactory as those previously in use, manufactured from imported timber. The cost of the work has been defrayed by the Union of South Africa. A total of 976 cases was examined and a detailed report embodying a number of suggestions whereby the boxes might be improved has been submitted.

Practical Trials of Empire Timbers

In the course of the year the following timbers have been subjected to practical trials at the Laboratory :—

Banak : *Virola merendonis* Pittier for sample boxes, rafters and studding.

Nigerian Celtis : *Celtis Soyauxii* Engl. for cabinet work.

East African Camphor : *Ocotea usambarensis* Engl. for insect breeding cages, window frames and doors.

Ceylon gurjun : *Dipterocarpus zeylanicus* Thw. for flooring and rafters.

Idigbo : *Terminalia ivorensis* A. Chev. for part of a cupboard.

Mora : *Mora excelsa* Benth. for window sills.

Musisi : *Maesopsis Eminii* Engl. for a filing cabinet.

Podo : *Podocarpus gracilior* Pilg. for a sign board.

Santa Maria : *Calophyllum brasiliense* var. *Rekoi*. Standl. for cloak cupboard.

By arrangement with other Government Departments and certain private firms, banak, East African celtis, Ceylon gurjun, and Santa Maria have also been undergoing service trials outside the Laboratory.

Appendix IIa

STANDING CONFERENCE ON TIMBER UTILIZATION

CONSTITUTION

Chairman :

Sir JOHN STIRLING MAXWELL, Bart., K.T.

Members appointed by the Department :

R. V. VERNON, Esq., C.B.
Major R. D. FURZE, D.S.O. } (Colonial Office).

Professor R. S. TROUP, C.M.G., C.I.E., D.Sc., F.R.S. (Imperial Forestry Institute).

SIR ARTHUR W. HILL, K.C.M.G., Sc.D., F.D.S. (Ministry of Agriculture and Fisheries, Royal Botanic Gardens, Kew).

J. P. FRASER, Esq.
S. E. CHANDLER, Esq., D.Sc. } (Imperial Institute).

W. A. ROBERTSON, Esq., Director, Forest Products Research (Department of Scientific and Industrial Research).

E. H. B. BOULTON, Esq. (Timber Development Association).

W. E. MCKEE, Esq.

Member appointed by the High Commissioner for a Dominion :

F. U. DU TOIT, Esq. (Union of South Africa).

Appendix IIb

RULES AND STANDING ORDERS OF THE STANDING CONFERENCE ON TIMBER UTILIZATION

1. *Objects*

The Department of Scientific and Industrial Research having agreed to hold available, for the assistance of the various parts of the Empire overseas, under financial arrangements to be approved from time to time by the Department, the facilities of its Forest Products Research Laboratory at Princes Risborough for the investigation of the qualities of particular timbers (which determine their uses) and for furnishing technical information of importance in marketing such timbers, it has been decided to establish a standing conference to act as a consultative and advisory body to the Department and to the various units of the Empire overseas which desire to make use of these facilities.

2. *Constitution*

Any Dominion, Colony, or other unit of the Empire overseas which makes use of these facilities will be entitled to appoint one or more representatives to membership of the Conference. The names of all representatives so appointed will be communicated to the Department by the Office of the appointing unit of Empire. The Department will appoint representatives to be members of the Conference, who may include persons nominated by other Departments of State in the United Kingdom interested in the use of Empire-grown timbers, a person or persons nominated by the Minister of Agriculture and Fisheries as representing the Royal Botanic Gardens at Kew, persons nominated by the Governing Bodies of the Imperial Institute and the Imperial Forestry Institute, persons nominated by any timber trade organisation in the United Kingdom on an invitation issued on the recommendation of the Standing Conference, and persons not included in the foregoing categories who have in the past been of conspicuous service, as members of the Empire Timbers Committee or otherwise, in promoting the use of Empire-grown timbers in the United Kingdom.

3. *The Year*

For the purpose of these rules and standing orders, the year is understood to run from January 1st to December 31st.

4. *Chairman*

The Chairman will be appointed by the Department from among the members of the Conference as defined by its constitution as set out in 2 above. He will hold office for three years, and will be eligible for reappointment for a further period, not exceeding three years, on the completion of a term of office.

5. *Secretarial work and place of meeting*

The Department will undertake the secretarial work of the Conference and will provide a place for its meetings.

6. *Meetings*

Three ordinary meetings of the Conference will be held in each year. A notice of the date, time and place of each ordinary meeting will be sent to each member one month before the meeting. A special meeting may be called at any time by the Chairman in his discretion and shall be called by the Chairman on the requisition of the representative, or if more than one, the representatives of any unit of the Empire appointing to membership of Conference, such requisition to be accompanied by notice of the question or questions to be raised at the meeting. At least one week's notice of the date, time and place of each special meeting will be sent to each member.

7. *Business*

The regulation of the business of the meetings of the Conference will be in the hands of the Chairman. A member wishing to bring any matter before a meeting of the Conference is requested to give notice to the Director, Forest Products Research Laboratory, Princes Risborough, Bucks., fourteen days before the meeting, so that the matter may be included as an item on the agenda. Matters to be so brought before the Conference would include those which bear on the marketing of any timber grown in the part of the Empire overseas which the member may represent. An agenda paper for each meeting will be circulated so as to reach members at least three days before the meeting.

8. *Presentation of reports to the Conference*

A brief progress report on the work carried out by the Department on Empire-grown timbers under the arrangements defined in 1 above during the period since the last ordinary meeting of the Conference will be presented to the Conference at each ordinary meeting by the Department. Members representing various units of the Empire overseas or the institutions or trade organisations defined in 2 above are invited to present similarly to the Conference progress reports on any work carried out by the unit of Empire, institution or organisation they represent which appears to be of general interest in promoting the objects of the Conference. Such reports should reach the Director, Forest Products Research Laboratory, at least fourteen days before the meeting at which they are to be presented.

9. *Reports of the proceedings of the Conference*

As soon as possible after December 31st in each year, the Conference will present to the bodies appointing members a report of its proceedings during the past year. These reports may be printed and published by the Department in its discretion.

APPENDIX III

LIST OF PUBLICATIONS

A.—*Stationery Office Publications**

	Price s.	d.
Report of the Forest Products Research Board for the period ended 30th September, 1928 .. .. (1929)	3	0
Report of the Forest Products Research Board for the period ended 31st December, 1929 .. .. (1930)	4	0
Report of the Forest Products Research Board for the year 1930 ..	4	0
Report of the Forest Products Research Board for the year 1931 ..	3	6
Report of the Forest Products Research Board for the year 1932 ..	4	0
Report of the Forest Products Research Board for the year 1933 ..	1	3

TECHNICAL PAPERS :—

No. 1.—The Movement of Moisture with reference to Timber Seasoning. By S. T. C. Stillwell, B.Sc. ..	(*Out of print*)	
No. 2.—Moisture Movement through Wood. The Steady State. By J. F. Martley, D.I.C., B.Sc... .. .. (1926)	1	3

SPECIAL REPORTS :—

No. 1.—The Air-Seasoning and Conditioning of Timber. By F. M. Oliphant .. .. (1927)	2	0
No. 2.—The Principles of Kiln-Seasoning of Timber. Part I.—Types of Commercial Kilns in Use. By S. T. C. Stillwell, B.Sc. .. .. (1928)	0	9
No. 3.—Practical Kiln-Drying. By W. C. Stevens, M.A., A.M.I.Mech.E. .. .. (1933)	1	6

BULLETINS :—

No. 1.—Dry Rot in Wood .. *Revised edition* (1933)	1	0
No. 2.—*Lyctus* Powder-Post Beetles. By Ronald C. Fisher, B.Sc., Ph.D. .. .. (*Out of print*)		
No. 3.—British Hardwoods. Their Structure and Identification. By L. Chalk, M.A., and B. J. Rendle, B.Sc. (1929)	5	0
No. 4.—Decay of Sitka Spruce Timber caused by *Trametes serialis* Fr. By K. St. G. Cartwright, B.A. (1930)	2	0
No. 5.—The Moisture Content of Wood with Reference to Furniture Manufacture. By S. T. C. Stillwell, B.Sc. (1930)	2	0
No. 6.—The Timber of Corsican Pine (*Pinus Laricio* Poiret) (1930)	2	6
No. 7.—Home-Grown Timbers. Their Anatomical Structure and its Relation to Physical Properties. Elm. By S. H. Clarke, B.Sc. .. .. (1930)	3	6
No. 8.—The Use of Home-Grown Larch Poles for Transmission Lines .. .. (1931)	2	0
No. 9.—Home-Grown Pitprops .. .. (1931)	2	0
No. 10.—The Timber of Home-Grown Douglas Fir .. (1931)	3	0

* *Obtainable from any of the Sale Offices of His Majesty's Stationery Office, LONDON : Adastral House, Kingsway, W.C.2 ; EDINBURGH, 120, George Street ; MANCHESTER : York Street ; CARDIFF : 1, St. Andrew's Crescent ; BELFAST : 80, Chichester Street.*

	Price s.	d.
BULLETINS *contd.* :—		
No. 11.—The Effect of Progressive Decay by *Trametes serialis* Fr. on the Mechanical Strength of the Wood of Sitka Spruce. By K. St. G. Cartwright, M.A., W. P. K. Findlay, M.Sc., C. J. Chaplin, M.Sc., and W. G. Campbell, B.Sc., M.S.	1	6
No. 12.—Some Characteristics of Home-Grown Timbers. By C. J. Chaplin, M.Sc., M.E.I.C., J. Latham, B.Sc., and F. H. Armstrong, M.Sc., A.M.I.M.E. .. (1931)	2	0
No. 13.—The Principles of Woodworking : A Survey of Present Knowledge on this Subject. By W. W. Barkas, M.Sc., E. D. van Rest, B.A., B.Sc., and W. E. Wilson (1932)	2	6
No. 14.—The Determination of the Moisture Content of Timber. By R. A. G. Knight, B.Sc.(Eng.) .. .. (1932)	1	0
No. 15.—The Timber of Home-grown Scots Pine. (*Pinus sylvestris* L.) .. .. (1932)	5	0
No. 16.—A Survey of the Damage caused by Insects to Hardwood Timbers in Great Britain. By Ronald C. Fisher, B.Sc., Ph.D., F. R. Cann, D.I.C., and E. A. Parkin, B.Sc., D.I.C. .. .. (1932)	2	6
PROJECTS :—		
Project 1.—Mechanical and Physical Properties of Timber. Tests of Small Clear Specimens. By C. J. Chaplin, M.Sc., M.E.I.C. .. .. (1928)	2	0
Project 1.—Progress Report 1. Tests of some Home-grown Timbers in their Green Condition. By C. J. Chaplin, M.Sc., M.E.I.C. .. .. (1928)	0	9
Project 1.—Progress Report 2. Tests of some Home-grown Timbers in their Green and Seasoned Conditions. By C. J. Chaplin, M.Sc., M.E.I.C., and F. M. Mooney, B.Sc., A.M.E.I.C. (1929)	1	0
MISCELLANEOUS :—		
The Uses of Home-grown Timber. *Compiled by a Committee comprising representatives of the Land Agents' Society, the Federated Home-Grown Timber Merchants' Association, the Royal Institute of British Architects, and the Forest Products Research Laboratory .. .. Revised edition* (1929)	1	0
LEAFLETS :—		
No. 1.—"Worm" in Furniture. (*Out of print. Superseded by Leaflets Nos.* 3, 4 *and* 8.)		
No. 2.—The Influence of Certain Factors on the Kiln-Drying of Timber and on the Choice of the Types of Drying Kiln. By S. T. C. Stillwell, B.Sc. .. .. (1928)		
No. 3.—*Lyctus* Beetles and Their Control .. .. (1930)		
No. 4.—The Death-Watch Beetle .. (*Revised edition*) (1933)		
No. 5.—Empire Timbers from Home and Overseas for Building and Structural Purposes. By Major J. R. Cosgrove, D.S.O., M.C., M.E.I.C. .. .. (1932)	1	3
No. 6.—Dry Rot in Buildings. Recognition, Prevention and Cure .. .. .. (*Revised edition*) (1933)		
No. 7.—Moisture Content Determination. By R. A. G. Knight (1932)		
No. 8.—The Common Furniture Beetle .. .. .. (1933)		

The unpriced leaflets above may be obtained only from the Director, Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks.

B.—*Other Publications.*

BARKAS, W. W.

Retention of Moisture by Wood. *Nature*, 1932, **130**, 699.

Measurement of the Cell Space Ratio in Wood by a Photo-electric Method. *Proc. phys. Soc.*, 1934, **46**, 545.

BATESON, R. G.

Timber Drying Kiln Instruments. Modern Equipment for Needs of To-day. Hints to assist the User in his Choice. *Timb. Tr. J.*, 1933, **125**, xxi, April 8th *et seq.* (Reprints of complete article, 6d. each.)

Modern Methods of Timber Drying. *Music Tr. Rev.*, 1934, No. 717, 287.

Some practical Aspects of the Shrinkage of Wood. *Timb.* (*Woodw. Mach.*), 1934, **67**, 842.

BRYAN, J.

Antiseptic Treatment of Home-Grown Conifers. *Emp. For. J.*, 1930, **9**, 236.

The Open Tank Process for Antiseptic Treatment of Timber for Estates, Farms, Collieries, etc. *J. Bath W. S. Co. Ass.* Sixth Series, 1930–1931, **5**.

Methods of Applying Antiseptics. *Forestry*, 1932, **6**, 75.

The Preservation of Railway Sleepers. *J. Brit. Wood Pres. Ass.*, 1933, **3**, 62.

The Preparation of Timber. Seasoning and Preservation for Industrial Purposes. *Timb. Tr. J.*, 1934, **130**, 680, 727.

CAMPBELL, W. G.

The Degradation of Wood by simultaneous Action of Ethyl Alcohol and Hydrochloric Acid. *Biochem. J.*, 1929, **23**, 1225.

Chemical Aspect of the Destruction of Oak Wood by Powder-post and Death-Watch Beetles. *Lyctus* spp. and *Xestobium* sp. *Biochem. J.*, 1929, **23**, 1290.

The Chemistry of the White Rots of Wood. I.—The Effect on Wood Substance of *Polystictus versicolor* (Linn.) Fr., *Biochem. J.*, 1930, **24**, 1235.

The Chemistry of the White Rots of Wood. II.—The Effect on Wood Substance of *Armillaria mellea* (Vahl.) Fr., *Polyporus hispidus* (Bull.) Fr., and *Stereum hirsutum* Fr. *Biochem. J.*, 1931, **25**, 2023.

The Chemistry of the White Rots of Wood. III.—The Effect on Wood Substance of *Ganoderma applanatum, Fomes fomentarius, Polyporus adustus, Pleurotus ostreatus, Armillaria mellea, Trametes pini*, and *Polystictus abietinus*. *Biochem. J.*, 1932, **26**, 1829.

A Chemical Approach to the Study of Wood Preservation. Forestry, 1932, **6**, 82.

A Modified Form of Apparatus for the Determination of Methoxyl Groups. *J. Soc. chem. Ind., Lond.*, 1932, **51**, 590.

CAMPBELL, W. G., and BOOTH, J.

The Effect of Partial Decay on the Alkali Solubility of Wood. *Biochem. J.*, 1929, **23**, 566.

The Chemical Aspect of the Drying of Timber—1. *Biochem. J.*, 1930, **24**, 641.

The Chemical Aspect of the Drying of Timber.—2. The Drying of a Softwood. *Biochem. J.*, 1931, **25**, 756.

CAMPBELL, W. G., and FISHER, R. C.

The Composition and Origin of "Stone" in Iroko Wood (*Chlorophora excelsis*). *Emp. For. J.*, 1932, **11**, 244.

CAMPBELL, W. G., and TAYLOR, K. F.
The Chemical Changes induced in Wood by saturated Steam under Pressure. *Biochem. J.*, 1933, **27**, 158.

CANN, F. R.
Laboratory Tests of Insecticides for use against Wood Boring Insects. *Ann. appl. Biol.*, 1932, **19**, 291.

CARTWRIGHT, K, ST. G.
Notes on a Fungus associated with *Sirex cyaneus*. *Ann. appl. Biol.*, 1929, **16**, 182.
Notes on Basidiomycetes Grown in Culture. *Trans. Brit. mycol. Soc.*, 1929, **14**, 300.
A Satisfactory Method of Staining Fungal Mycelium in Wood Sections. *Ann. Bot., Lond.*, 1929, **43**, 170.
The Toxicity of Preservatives against Wood-Destroying Fungi. *Forestry*, 1931, **5**, 138.
Further Notes on Basidiomycetes in Culture. *Trans. Brit. mycol. Soc.*, 1932, **16**, 304.
Diseases of Timber. *J. Brit. Wood Pres. Ass.*, 1932, **2**, 18.
Stain and Discolouration in Timber. *Timber Tr. J.*, 1933, **127**, 375.

CARTWRIGHT, K. ST. G., and FINDLAY, W. P. K.
The Diagnosis of Decay in Timber. *Emp. For. J.*, 1930, **9**, 190.
Studies in the Physiology of Wood-Destroying Fungi.—II. Temperature and Rate of Growth. *Ann. Bot., Lond.*, 1934, **48**, 481.

CHAPLIN, C. J.
Application of Timber Testing. Paper read before the *British Association*, 1926.
Mechanical Testing of Timber and its Impregnation against Dry Rot and Fire. *First Communication of the New International Association for the Testing of Materials*. Zürich, 1930, p. 94.
The Development of the Mechanical Testing of Timber in Great Britain, with a Note on Preservative Treatments. Paper read before the *First Congress of the New International Association for Testing Materials* at Zürich, 1931.

CHAPLIN, C. J., and RENDLE, B. J.
A Note on some Structural and Mechanical Characteristics of Benmore Douglas Fir. *Forestry*, 1929, **3**, 87.

CLARKE, S. H.
On the Relationship between Vessel Size and *Lyctus* Attack in Timber. *Forestry*, 1928, **2**, 47.
The Tertiary Wall of Wood Fibres. Paper read before the *British Association*, 1930.
The Use of the Projection Apparatus in Anatomical Studies of Timbers. *Forestry*, 1930, **4**, 40.
The Differential Shrinkage of Wood. *Forestry*, 1930, **4**, 93.
On Estimating the Mechanical Strength of the Wood of Ash (*Fraxinus excelsior* L.). *Forestry*, 1933, **7**, 26.

COSGROVE, J. R.
Empire Timbers. *Archit. Diary and Tech. Ref.*, 1933.

COX, H. A.
Some Empire Timbers. *Timb. Tr. J.*, 1934, **129**, 928.
Empire Timbers in 1933. *Emp. For. J.*, 1934, **13**, 58.
Timbers for Decoration. *Archit. Rev., Lond.*, 1934, **76**, 64.

FINDLAY, W. P. K.
Dry Rot, its Cause, Prevention and Cure. *Archit. (Build.) J.*, August-September, 1930.
Laboratory Materials for Testing Wood Preservatives. *Ann. appl. Biol.*, 1932, **19**, 271.

FINDLAY, W. P. K.—*contd.* :—
A Study of *Paxillus panuoides* Fr. and its Effect upon Wood. *Ann. appl. Biol.*, 1932, **19**, 331.
Note on Germination of the Spores of *Merulius lacrymans* (Wolf.) Fr. *Trans. Brit. mycol. Soc.*, 1933, **17**, 304.
Prevention of Decay in Garden Timber. *Gdnrs.' Chron.*, 1933, **94**, 477.
The Durability of Western Red Cedar, *Thuya plicata*. *Emp. For. J.*, 1933, **12**, 239.
Studies in the Physiology of Wood-destroying Fungi. I. The Effect of Nitrogen Content upon Rate of Decay of Timber. *Ann. Bot., Lond.*, 1934, **48**, 109.
Tests on the Natural Durability of Timbers. *Timb.* (*Woodw. Mach.*), 1934, **66**, 1368.

FISHER, R. C.
Recent Work on Insects Injurious to Timber. Paper read before the *British Association*, 1928.
Timbers and their Condition in relation to *Lyctus* Attack. *Forestry*, 1928, **2**, 40.
The Relation of the Elm Bark Beetles to their Host Trees. *Forestry*, 1928, **2**, 53.
Notes on the Biology of the Large Elm Bark Beetle, *Scolytus destructor*. *Forestry*, 1931, **5**, 120.
Some Aspects of the *Lyctus* Problem in Great Britain. *V^e Int. Congr. Ent.*, 1932, 757.
Prevention and Control of Damage by Wood-boring Insects. *Forestry*, 1932, **6**, 67.
Defects in Timber caused by Pin-hole Borers. *Timb. Tr. J.*, 1933, **126**, 281.

FISHER, R. C., and PARKIN, E. A.
Presence of a Yeast in the Death-Watch Beetle (*Xestobium rufovillosum*, DeG.). *Nature*, 1930, **125**, 892.

HARRIS, P.
Research in Woodworking. *Timb. Tr. J.*, September 10 and 17, 1932, **122**, xxiii and xxix ; also in *Engineering*, 1933, **135**, 27.
Woodworking Research. *Timb. Tr. J.*, 1932, **123**, 843 ; also in *Timb.* (*Woodw. Mach.*), 1932, **63**, 1172 ; and in *Timb. News Sawm. Engr.*, 1933, No. 1986, 42.
Circular Saws. Their Efficient Operation. *Timb.* (*Woodw. Mach.*), 1933, **64**, 105.
Woodworking Research. Effect of Variation of Cutting Angle. *Timb.* (*Woodw. Mach.*), 1934, **66**, 222.
The Importance of Correct Cutting Angles in Machining. *Emp. For. J.*, 1934, **13**, 63.
State Research makes Savings in your Sawmill. *Furniture Mfr.*, 1934, **3**, 220.

KNIGHT, R. A. G.
The Moisture Content of Wood in Relation to Hygrometric Conditions. Paper read before the *British Association*, 1930.
The Dry Weight of Wood. *Forestry*, 1931, **5**, 57.
Moisture Content of Wood. *Timb. Tr. J.*, 1930, **115**, 537.
Development of a New Type of Timber Drying Kiln. *Timb. Tr. J.*, 1932, **121**, 78.
Timber Drying Kilns. *Timb. Tr. J.*, 1932, **121**, 214.
Case-hardening of Timber. *Timb.* (*Woodw. Mach.*), 1933, **65**, 1089.
Natural Draught Kiln. Evolution of a new Pattern. *Timb. Tr. J.*, **127**, December 30th, 1933, xix.
Testing the Fire Resistance of Timber. *Timb. Tr. J.*, 1934, **131**, 247.
The Seasoning of Timber. Paper read before *British Wood Preserving Association*, 1934.

LATHAM, J.
Mechanical Strength Tests of Australian Hardwood Poles. *Timb. (Woodw. Mach.)*, 1933, **65**, 526.

LATHAM, J., and ARMSTRONG, F. H.
The Mechanical Strength Properties of 'Brown' Oak. *Forestry*, 1934, **8**, 131.

MABY, J. C.
Report on Wood Fragments from the Remains of a Lake Settlement at Auvernier (Neuchatel). *Antiquity*, Dec., 1928, p. 472.

MARTLEY, J. F.
Moisture Movement in Wood. I.—The Transfer of Moisture between Two Discs of Wood. *Ann. appl. Biol.*, 1926, **13**, 37.
Comparisons between Kauri Pine and Swamp Kauri (*Agathis australis*). *Ann. appl. Biol.*, 1927, **14**, 4.
The Work of the Oxford Branch, Forest Products Research Laboratory. *Ann. appl. Biol.*, 1928, **15**, 3.
Research in Wood Structure. *Forestry*, 1928, **2**, 62.
Theoretical Calculation of the Pressure Distribution on the Basal Section of a Tree. *Forestry*, 1928, **2**, 69.

NUTMAN, F. J.
Studies with Wood-destroying Fungi. I.—*Polyporus hispidus* (Fr.). *Ann. appl. Biol.*, 1929, **16**, 40.

O'DWYER, M. H.
The Hemicelluloses of American White Oak. *Biochem. J.*, 1923, **17**, 501.
A Note on the Occurrence of a Pectic Substance in Beech Wood. Part IV. The Hemicelluloses. *Biochem. J.*, 1925, **19**, 694.
Preliminary Investigations on the Constitution of the Hemicelluloses of Timber. *Biochem. J.*, 1928, **22**, 381.
The Hemicelluloses of Beech Wood. *Biochem. J.*, 1926, **20**, 656.
The Hemicelluloses of the Wood of English Oak. I.—The Effect of the Drying of Wood on the Yields and Composition of Hemicellulose A. *Biochem. J.*, 1931, **25**, 2,017.
Recent Advances in the Study of the Chemistry of the Hemicelluloses of Wood. *J. Soc. chem. Ind., Lond.*, 1932, **51**, 968.
The Hemicelluloses of the Wood of English Oak. II.—The Composition and Properties of Hemicellulose A, isolated from samples of Wood dried under various Conditions. *Biochem. J.*, 1934, **28**, 2116.

OLIPHANT, F. M.
Forest Products Research in Great Britain. *Forestry*, 1927, **1**, 47.
The Efficient Use of Timber. Work of the Forest Products Research Laboratory. *Archit. Diary and Tech. Ref.*, 1933.

PARKIN, E. A.
The Larvæ of Some Wood-boring Anobiidæ. *Bull. ent. Res.*, 1933, **24**, 33.
The Occurrence of the Longhorn Beetle, *Hylotrupes bajulus* L., in England. *Forestry*, 1934, **8**, 150.
Observations on the Biology of the *Lyctus* Powder Post Beetles, with special Reference to Oviposition and the Egg. *Ann. appl. Biol.*, 1934, **21**, 495.

PEARSON, R. S.
Hardwoods. *Forestry*, 1928, **2**, 10.
Wood Preservation: An Introduction. *Forestry*, 1931, **5**, 136.
The Problem of Creating and Developing Markets for Empire Hardwood Timbers at Home. *Emp. For. J.*, 1933, **12**, 11.

PHILLIPS, E. W. J.
Movement of the Pit Membrane in Coniferous Woods with Special Reference to Preservative Treatment. *Forestry*, 1933, **7**, 109.

RENDLE, B. J.
Recent Research on the Microchemical Reactions of Woody Tissues. *Forestry*, 1930, **4**, 50.
Conference on the Systematic Anatomy of Wood. *Forestry*, 1930, **4**, 128.
The Place of Wood Anatomy in Forest Products Research. Paper read before the *Congres international du Bois et de la Sylviculture*, Paris, 1931.
Wood Anatomy as a Link between Botany and Forestry. *Nature*, 1932, **130**, 834.
The Botanical Classification of Timbers. *Timb. Tr. J.*, 1934, **128**, 388.

RENDLE, B. J., and CLARKE, S. H.
The Problem of Variation in the Structure of Wood. *Trop. Woods*, 1934, No. 38, 1.
The Diagnostic Value of Measurements in Wood Anatomy. *Trop. Woods*, 1934, No. 40, 27.

RICHARDSON, N. A.
A Note on Creosotes extracted from Old Timbers. *J. Soc. chem. Ind., Lond.*, 1934, **53**, 710.
Coal-tar Creosote Oil as a Wood Preservative. *J. Brit. Wood. Pres. Ass.*, 1934, **4**, 64.

STEEL, E. A.
The Design of Kilns for the Seasoning of Timber. *Timb. News Sawm. Engr.*, 1933, **43**, 319; also in *J. Jr Instn Engrs.*, 1933, **43**, 319.

STEVENS, W. C.
The Steam Bending of Timber. *Timb. News Sawm. Engr.*, 1933, **42**, 161.
A Machine Design for Wood-bending Research. *Timb. (Woodw. Mach.)*, 1933, **65**, 1556.

STILLWELL, S. T. C.
The Seasoning of Timber. *Forestry*, 1930, **4**, 34.
"Collapse" in Timber. *Timb. Tr. J.*, 1931, **116**, 500.
The Seasoning or Drying of Timber. *Trans. Instn chem. Engrs., Lond.*, 1928, **6**, 91.
The Seasoning of Timber for High-Class Joinery and Decorative Work for Public Buildings. *J. R. Inst. Brit. Archit.*, 1932, **39**, 410.
The Shrinkage of Wood (Oak and Teak). *Emp. For. J.*, 1933, **12**, 265.
Elm as a Decorative Wood. *Ctry. Life, Lond.*, 1934, **76**, No. 1976, lviii, lx.

STILLWELL, S. T. C., and STEVENS, W. C.
Elm, Beech and Ash. High-temperature Steaming. *Timb. Tr. J.*, 1931, **119**, 752.
Timber Seasoning. Some Important Factors affecting the Steam Consumption in Timber Drying Kilns. *Timb. Tr. J.*, 1933, **125**, 411.

VAN REST, E. D.
A Method for the Measurement of the Thermal Diffusivity of Poor Conductors. *Proc. phys. Soc.*, 1934, **46**, 537.

VAN REST, E. D., and PARKIN, E. A.
Poisson Series and Biological Data. *Nature*, 1933, **132**, 445.

WILSON, W. E.
Woodworking Machinery, with special Reference to the Building Trade. *Forestry*, 1929, **3**, 57.

Machining of Canadian Birch (*Betula lutea*). *Timb. (Woodw. Mach.)*, 1934, **66**, 1132; also in *Timb. Tr. J.*, 1934, **129**, No. 3011, xxv.

Preliminary Note on the Timber of Home-grown Sitka Spruce (*Picea sitchensis* Carr.). *Forestry*, 1934, **8**, 126.

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